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PALEY'S

NATURAL THEOLOGY,

WITH ILLUSTRATIVE NOTES, &c.

BY HENRY LORD BROUGHAM, F.R.S.,

AND

SIR CHARLES BELL, K.G.H., F.R.S., L. & E.

TO WHICH ARE ADDED

PRELIMINARY OBSERVATIONS AND NOTES.

BY A. POTTER, D.D.

IN TWO VOLUMES.

VOL. II.

New-York:

HARPER & BROTHERS, 82 CLIFF-ST.

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BY A. POTTER, D.D.,

PROFESSOR OF MORAL PHILOSOPHY IN UNION COLLEGE.

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NATURAL THEOLOGY.

CHAPTER XVII.

THE RELATION OF ANIMATED BODIES TO INANIMATE NATURE.

We have already considered *relation*, and under different views; but it was the relation of parts to parts, of the parts of an animal to other parts of the same animal, or of another individual of the same species.

But the bodies of animals hold, in their constitution and properties, a close and important relation to natures altogether external to their own; to inanimate substances, and to the specific qualities of these; e. g., *they hold a strict relation to the* ELEMENTS *by which they are surrounded.*

I. Can it be doubted whether the *wings of birds* bear a relation to air, and the *fins of fish* to water? They are instruments of motion severally suited to the properties of the medium in which the motion is to be performed; which properties are different. Was not this difference contemplated when the instruments were differently constituted?

II. The structure of the animal *ear* depends for its use not simply upon being surrounded by a fluid, but upon the specific nature of that fluid. Every fluid would not serve: its particles must repel one another; it must form an elastic medium: for it is by the successive pulses of *such* a medium that the undulations excited by the surrounding body are carried to the organ; that a communication is formed between the object and the sense; which must be

done before the internal machinery of the ear, subtile as it is, can act at all.

III. The *organs* of voice and respiration are, no less than the ear, indebted, for the success of their operation, to the peculiar qualities of the fluid in which the animal is immersed. They therefore, as well as the ear, are constituted upon the supposition of such a fluid, *i. e.*, of a fluid with such particular properties, being always present. Change the properties of the fluid, and the organ cannot act: change the organ, and the properties of the fluid would be lost. The structure, therefore, of our organs, and the properties of our atmosphere, are made for one another. Nor does it alter the relation, whether you allege the organ to be made for the element (which seems the most natural way of considering it), or the elements as prepared for the organ.

IV. But there is another fluid with which we have to do; with properties of its own; with laws of acting, and of being acted upon, totally different from those of air and water; and that is *light*. To this new, this singular element, to qualities perfectly peculiar, perfectly distinct and remote from the qualities of any other substance with which we are acquainted, an organ is adapted, an instrument is correctly adjusted, not less peculiar among the parts of the body, not less singular in its form and in the substance of which it is composed, not less remote from the materials, the model, and the analogy of any part of the animal frame, than the element to which it relates is specific amid the substances with which we converse. If this does not prove appropriation, I desire to know what would prove it.

Yet the element of light and the organ of vision, however related in their office and use, have no connexion whatever in their original. The action of rays of light upon the surfaces of animals has no tendency to breed eyes in their heads. The sun might shine for ever upon living bodies without the smallest approach towards producing the sense of sight. On

the other hand, also, the animal eye does *not* generate or emit light.

V. Throughout the universe there is a wonderful *proportioning* of one thing to another. The size of animals, the human animal especially, when considered with respect to other animals, or to the plants which grow around him, is such as a regard to his convenience would have pointed out. A giant or a pigmy could not have milked goats, reaped corn, or mowed grass; we may add, could not have rode a horse, trained a vine, shorn a sheep, with the same bodily ease as we do, if at all. A pigmy would have been lost among rushes, or carried off by birds of prey.

It may be mentioned, likewise, that the model and the materials of the human body being what they are, a much greater bulk would have broken down by its own weight. The persons of men who much exceed the ordinary stature betray this tendency.

VI. Again (and which includes a vast variety of particulars, and those of the greatest importance), how close is the *suitableness* of the earth and sea to their several inhabitants and of these inhabitants to the places of their appointed residence!

Take the *earth* as it is, and consider the correspondence of the powers of its inhabitants with the properties and condition of the soil which they tread. Take the inhabitants as they are, and consider the substances which the earth yields for their use. They can scratch its surface, and its surface supplies all which they want. This is the length of their faculties; and such is the constitution of the globe, and their own, that this is sufficient for all their occasions.

When we pass from the earth to the *sea*, from land to water, we pass through a great change: but an adequate change accompanies us of animal forms and functions, of animal capacities and wants; so that *correspondence* remains. The earth, in its nature, is very different from the sea, and the sea from the earth, but one accords with its inhabitants as exactly as the other.

VII. The last relation of this kind which I shall mention is that of *sleep* to *night;* and it appears to me to be a relation which was expressly intended. Two points are manifest; first, that the animal frame requires sleep; secondly, that night brings with it a cessation of activity which allows of sleep being taken without interruption and without loss. Animal existence is made up of action and slumber; nature has provided a season for each. An animal which stood not in need of rest would always live in daylight. An animal which, though made for action and delighting in action, must have its strength repaired by sleep, meets, by its constitution, the return of day and night. In the human species, for instance, were the bustle, the labour, the motion of life upheld by the constant presence of light, sleep could not be enjoyed without being disturbed by noise, and without expense of that time which the eagerness of private interest would not contentedly resign. It is happy, therefore, for this part of the creation, I mean that it is conformable to the frame and wants of their constitution, that nature, by the very disposition of her elements, has commanded, as it were, and imposed upon them, at moderate intervals, a general intermission of their toils, their occupations, and pursuits.

But it is not for man, either solely or principally, that night is made. Inferior but less perverted natures taste its solace, and expect its return with greater exactness and advantage than he does. I have often observed, and never observed but to admire, the satisfaction, no less than the regularity, with which the greatest part of the irrational world yield o this soft necessity, this grateful vicissitude; how comfortably the birds of the air, for example, address themselves to the repose of the evening, with what alertness they resume the activity of the day.

Nor does it disturb our argument to confess that certain species of animals are in motion during the night and at rest in the day. With respect even to them, it is still true that there is a change of condition in the animal, and an external change corre-

sponding with it. There is still the relation, though inverted. The fact is, that the repose of other animals sets these at liberty, and invites them to their food or their sport.

If the relation of *sleep* to *night*, and, in some instances, its converse, be real, we cannot reflect without amazement upon the extent to which it carries us. Day and night are things close to us: the change applies immediately to our sensations; of all the phenomena of nature, it is the most obvious and the most familiar to our experience; but, in its cause, it belongs to the great motions which are passing in the heavens. While the earth glides round her axle, she ministers to the alternate necessities of the animals dwelling upon her surface, at the same time that she obeys the influence of those attractions which regulate the order of many thousand worlds. The relation, therefore, of sleep to night is the relation of the inhabitants of the earth to the rotation of their globe; probably it is more, it is a relation to the system of which that globe is a part; and, still farther, to the congregation of systems of which theirs is only one. If this account be true, it connects the meanest individual with the universe itself; a chicken roosting upon its perch, with the spheres revolving in the firmament.[1]

[1] Nothing is more true than that the strength of the bones and the power of the muscles stand in intimate relation with the weight of the body, that is, also, in relation with the attraction of the globe itself. It is no less certain that many of the living properties of animals, the condition of the nervous system, and the alternation of exertion and repose in the muscular system, are related to the change of day and night, or to the revolving of our planet upon its axis. In man we may see a slight deviation in his habits and occupations from this correspondence with the succession of light and darkness; yet he enjoys a return of energy and elasticity of spirits, which is followed by weariness and exhaustion; and health will not long continue without yielding to the alternate condition of activity and repose. In nothing do we see the benevolence of the Creator more than in the continued gratification consequent on this arrangement alone, and more especially in the brutes. It is not a mere effect of light and the freshness of the morning which produce the almost universal

VIII. But if any one object to our representation, that the succession of day and night, or the rotation of the earth upon which it depends, is not resolvable into central attraction, we will refer him to that which certainly is—to the change of the seasons.

animation and activity of that time of day; for to many animals the light of day is the signal to seek repose; and that it is not the mere necessity which brings animals abroad at night, in order to feed secluded, or escape their enemies, we know from this, that their organs are adapted to the obscurer light, and not their organs only, but their propensities; for they are as full of activity and enjoyment as the things of day. The history of pulmonary and other complaints indicates a curious connexion between the functions of the body and the revolution of time or alternations of day and night.

But the most remarkable accommodation of the economy of animals, and of the property of life itself in them, regards the changes of the year rather than the diurnal change. How much this prevails in the vegetable world, we have only to look around us fully to comprehend. With the diminution of heat vegetation is nipped, the ova of insects locked up, and the food of many animals withdrawn. Some animals could not be protected by an instinct of migration, being without the means of passage: the bat could not fly away with the swallow, nor the hedgehog and dormouse travel with the deer. To sustain the animal heat against the low temperature of the surrounding atmosphere, requires a vigorous circulation of the blood, and a plentiful and uninterrupted supply of food. Many animals must, therefore, have died during the winter, had not nature supplied a means of their continuance in life beyond the ingenuity of man to conceive. The warmth of their clothing, and the instincts to build themselves a warm habitation, which we should almost say were the exercise of ingenuity, are insufficient. To sustain life, they must hold it by a new tenure. Accordingly, the necessity for food is removed; the activity of the circulation is diminished remarkably; a torpor seizes upon every living faculty, and they fall into what seems a long sleep. Yet it is not sleep, but a new condition of existence, in which life is preserved without the necessity for food, and when all the functions of the system are let down to a lower state of activity. And justly, therefore, it has been said, that in these things we trace the benevolence of the Creator, "who did not cast his living creatures into the world to prosper or perish as they might find it suited to them or not, but fitted together with the nicest skill the world and the constitution which he gave to its inhabitants; so fashioning it that light and darkness, sun and air, moist and dry, should become their ministers and benefactors, the unwearied and unfailing causes of their well-being." — *Whewell's Bridgewater Treatise.*

Now the constitution of animals susceptible of torpor bears a relation to winter similar to that which sleep bears to night. Against not only the cold, but the want of food, which the approach of winter induces, the Preserver of the world has provided in many animals by migration, in many others by torpor. As one example out of a thousand, the bat, if it did not sleep through the winter, must have starved, as the moths and flying insects upon which it feeds disappear. But the transition from summer to winter carries us into the very midst of physical astronomy; that is to say, into the midst of those laws which govern the solar system at least, and probably all the heavenly bodies.

CHAPTER XVIII.

INSTINCTS.

The order may not be very obvious by which I place *instincts* next to relations. But I consider them as a species of relation. They contribute, along with the animal organization, to a joint effect, in which view they are related to that organization. In many cases they refer from one animal to another animal; and, when this is the case, become strictly relations in a second point of view.

An instinct is a propensity prior to experience and independent of instruction. We contend that it is by *instinct* that the sexes of animals seek each other; that animals cherish their offspring; that the young quadruped is directed to the teat of its dam; that birds build their nests and brood with so much patience upon their eggs; that insects which do not sit upon their eggs deposite them in those particular situations in which the young, when hatched, find their appropriate food: that it is instinct which carries the

salmon and some other fish out of the sea into rivers, for the purpose of shedding their spawn in fresh water.

We may select out of *this* catalogue the incubation of eggs. I entertain no doubt but that a couple of sparrows hatched in an oven, and kept separate from the rest of their species, would proceed as other sparrows do in every office which related to the production and preservation of their brood. Assuming this fact,[2] the thing is inexplicable upon any other hypothesis than that of an instinct impressed upon the constitution of the animal. For, first, what should induce the female bird to prepare a nest before she lays her eggs? It is in vain to suppose her to be possessed of the faculty of reasoning; for no reasoning will reach the case. The fullness or distension which she might feel in a particular part of the body, from the growth and solidity of the egg within her, could not possibly inform her that she was about to produce something, which, when produced, was to be preserv-

[2] There can be very little doubt of this assumption being according to the fact. Nevertheless, as the experiment has probably not been actually made, there is no harm in mentioning one or two examples of the same import, and which are ascertained by repeated observation. When caterpillars bred upon a tree are shaken off and fall for the first time upon the ground, they immediately regain the tree by crawling up as quick as they can. Again: it is a very general law of insects, that the grub feeds upon a food which the parent does not eat, and yet the latter makes provision for the grub. Thus the solitary wasp deposites its eggs, each in a hole, and then collects a certain number of green worms, which she rolls up and deposites in the same hole, over the egg. When the grub is hatched, it feeds upon these worms until transformed into a young wasp. And here two things are remarkable: first, the wasp itself never feeds upon the worm, or, indeed, on any animal food: and next, M. Reaumur found that she provides just enough of the worms to sustain the grub till it becomes a fly, and changes its food. Our author dwells afterward upon the application to the argument of the fact that the parent insect never sees its young. The architecture of bees affords perhaps the most striking illustration; for those which have been taken without ever having any communication with the former race, build precisely in the accustomed manner. See the next note.

ed and taken care of. Prior to experience, there was nothing to lead to this inference or to this suspicion. The analogy was *all* against it; for, in every other instance, what issued from the body was cast out and rejected.

But, secondly, let us suppose the egg to be produced into day; how should birds know that their eggs contain their young? There is nothing either in the aspect or in the internal composition of an egg which could lead even the most daring imagination to conjecture that it was hereafter to turn out from under its shell a living perfect bird. The form of the egg bears not the rudiments of a resemblance to that of the bird. Inspecting its contents, we find still less reason, if possible, to look for the result which actually takes place. If we should go so far as, from the appearance of order and distinction in the disposition of the liquid substances which we noticed in the egg, to guess that it might be designed for the abode and nutriment of an animal (which would be a very bold hypothesis), we should expect a tadpole dabbling in the slime, much more than a dry, winged, feathered creature, a compound of parts and properties impossible to be used in a state of confinement in the egg, and bearing no conceivable relation, either in quality or material, to anything observed in it. From the white of an egg, would any one look for the feather of a goldfinch? or expect from a simple uniform mucilage the most complicated of all machines, the most diversified of all collections of substances? Nor would the process of incubation, for some time at least, lead us to suspect the event. Who that saw red streaks shooting in the fine membrane which divides the white from the yolk, would suppose that these were about to become bones and limbs? Who that espied two discoloured points first making their appearance in the cicatrix, would have had the courage to predict that these points were to grow into the heart and head of a bird? It is difficult to strip the mind of its experience. It is difficult to resuscitate surprise when familiarity has once laid the sentiment asleep. But

could we forget all that we know, and which our sparrows never knew, about oviparous generation; could we divest ourselves of every information but what we derived from reasoning upon the appearances or quality discovered in the objects presented to us, I am convinced that Harlequin coming out of an egg upon the stage is not more astonishing to a child than the hatching of a chicken both would be, and ought to be, to a philosopher.[3]

But admit the sparrow by some means to know that within that egg was concealed the principle of a future bird: from what chymist was she to learn that *warmth* was necessary to bring it to maturity, or that the degree of warmth imparted by the temperature of her own body was the degree required?

To suppose, therefore, that the female bird acts in this process from a sagacity and reason of her own, is to suppose her to arrive at conclusions which there are no premises to justify. If our sparrow, sitting upon her eggs, expect young sparrows to come out of them, she forms, I will venture to say, a wild and extravagant expectation, in opposition to present appearances and to probability. She must have penetrated into the order of nature farther than any faculties of ours will carry us; and it hath been well observed, that this deep sagacity, if it be sagacity, subsists in conjunction with great stupidity, even in relation to the same subject. "A chymical operation," says Addison, "could not be followed with greater art or diligence than is seen in hatching a

[3] The manner in which the chicken breaks the egg is one of the most wonderful operations of instinct, and is a process marked by the uniformity of instincts. For as all bees build alike with respect to the size of the cell and the angles at which its planes are inclined, so M. Reaumur found that all chickens chip the shell in the same direction, from left to right; and that the circle in which they chip invariably cuts the egg at right angles to its transverse axis, and not obliquely. The instrument which the chicken employs is a small protuberance on its upper mandible, called the *bill-scale*, which has no other use, and accordingly drops off soon after the bird is hatched. If any one should consider this as a different operation in kind from those usually ascribed to instinct in animals that are formed, a little reflection wil probably show him the impossibility of drawing any such line of distinction.

chicken: yet is the process carried on without the least glimmering of thought or common sense. The hen will mistake a piece of chalk for an egg; is insensible of the increase or diminution of their number; does not distinguish between her own and those of another species; is frightened when her supposititious breed of ducklings take to the water."

But it will be said that what reason could not do for the bird, observation, or instruction, or tradition might. Now if it be true that a couple of sparrows, brought up from the first in a state of separation from all other birds, would build their nest and brood upon their eggs, then there is an end of this solution. What can be the traditionary knowledge of a chicken hatched in an oven?

Of young birds taken in their nests, a few species breed when kept in cages; and they which do so build their nests nearly in the same manner as in the wild state, and sit upon their eggs. This is sufficient to prove an instinct, without having recourse to experiments upon birds hatched by artificial heat, and deprived from their birth of all communication with their species; for we can hardly bring ourselves to believe that the parent bird informed her unfledged pupil of the history of her gestation, her timely preparation of a nest, her exclusion of the eggs, her long incubation, and of the joyful eruption at last of her expected offspring: all which the bird in the cage must have learned in her infancy if we resolve her conduct into *institution.*

Unless we will rather suppose that she remembers her own escape from the egg, had attentively observed the conformation of the nest in which she was nurtured, and had treasured up her remarks for future imitation; which is not only extremely improbable (for who that sees a brood of callow birds in their nest can believe that they are taking a plan of their habitation?), but leaves unaccounted for one principal part of the difficulty, "the preparation of the nest before the laying of the egg." This she could not gain from observation in her infancy.

It is remarkable, also, that the hen sits upon eggs which she has laid without any communication with the male, and which are therefore necessarily unfruitful. That secret she is not let into. Yet, if incubation had been a subject of instruction or of tradition, it should seem that this distinction would have formed part of the lesson; whereas the instinct of nature is calculated for a state of nature; the exception here alluded to taking place chiefly, if not solely, among domesticated fowls, in which nature is forced out of her course.

There is another case of oviparous economy, which is still less likely to be the effect of education than it is even in birds, namely, that of *moths* and *butterflies*, which deposit their eggs in the precise substance, that of a cabbage for example, from which, not the butterfly herself, but the caterpillar which is to issue from her egg, draws her appropriate food. The butterfly cannot taste the cabbage: cabbage is no food for her; yet in the cabbage, not by chance but studiously and electively, she lays her eggs. There are, among many other kinds, the willow-caterpillar and the cabbage-caterpillar; but we never find upon a willow the caterpillar which eats the cabbage, nor the converse. This choice, as it appears to me, cannot in the butterfly proceed from instruction. She had no teacher in her caterpillar state. She never knew her parent. I do not see, therefore, how knowledge acquired by experience, if it ever were such, could be transmitted from one generation to another. There is no opportunity either for instruction or imitation. The parent race is gone before the new brood is hatched. And if it be original reasoning in the butterfly, it is profound reasoning indeed. She must remember her caterpillar state, its tastes and habits, of which memory she shows no signs whatever. She must conclude from analogy (for here her recollection cannot serve her), that the little round body which drops from her abdomen will, at a future period, produce a living creature, not like herself, but like the caterpillar which she remembers herself once to have been.

Under the influence of these reflections, she goes about to make provision for an order of things which she concludes will some time or other take place. And it is to be observed, that not a few out of many, but that all butterflies, argue thus; all draw this conclusion, all act upon it.

But suppose the address, and the selection, and the plan, which we perceive in the preparations which many irrational animals make for their young, to be traced to some probable origin, still there is left to be accounted for that which is the source and foundation of these phenomena, that which sets the whole at work, the *στοργη*, the parental affection, which I contend to be inexplicable upon any other hypothesis than that of instinct.

For we shall hardly, I imagine, in brutes, refer their conduct towards their offspring to a sense of duty or of decency, a care of reputation, a compliance with public manners, with public laws, or with rules of life built upon a long experience of their utility. And all attempts to account for the parental affection from association, I think, fail. With what is it associated? Most immediately with the throes of parturition, that is, with pain, and terror, and disease. The more remote, but not less strong association, that which depends upon analogy, is all against it. Everything else which proceeds from the body is cast away and rejected. In birds, is it the egg which the hen loves? or is it the expectation which she cherishes of a future progeny that keeps her upon her nest? What cause has she to expect delight from her progeny? Can any rational answer be given to the question, why, prior to experience, the brooding hen should look for pleasure from her chickens? It does not, I think, appear that the cuckoo ever knows her young; yet, in her way, she is as careful in making provision for them as any other bird. She does not leave her egg in every hole.[4]

[4] "The cuckoo," says Willoughby, "herself builds no nest; but, having found the nest of some little bird, she either devours or destroys the eggs she there finds, and, in the room thereof, lays

The salmon suffers no surmountable obstacle to oppose her progress up the stream of fresh rivers. And what does she do there? She sheds a spawn, which she immediately quits in order to return to the sea; and this issue of her body she never afterward recognises in any shape whatever. Where shall we find a motive for her efforts and her perseverance? Shall we seek it in argumentation or in instinct? The violet crab of Jamaica performs a fatiguing march of some months' continuance, from the mountains to the sea-side. When she reaches the coast, she casts her spawn into the open sea, and sets out upon her return home.

Moths and butterflies, as hath already been observed, seek out for their eggs those precise situations and substances in which the offspring caterpillar will find its appropriate food. That dear caterpillar the parent butterfly must never see. There are no experiments to prove that she would retain any knowledge of it if she did. How shall we account for her conduct? I do not mean for her art and judgment in selecting and securing a maintenance for her young, but for the impulse upon which she acts. What should induce her to exert any art, or judgment, or choice about the matter? The undisclosed grub, the animal which she is destined not to know, can hardly be the object of any particular affection, if we deny the influence of instinct. There is nothing, therefore, left to her, but that of which her nature seems incapable, an abstract anxiety for the general preservation of the species; a kind of patriotism; a solicitude lest the butterfly race should cease from creation.

Lastly, the principle of association will not explain the discontinuance of the affection when the young animal is grown up. Association operating in its usual way would rather produce a contrary effect.

one of her own, and so forsakes it. The silly bird, returning, sits on the egg, hatches it, and, with a great deal of care and toil, broods, feeds, and cherishes the young cuckoo for her own, until it be grown up, and able to fly and shift for herself."—*Am. Ed.*

The object would become more necessary by habits of society; whereas birds and beasts, after a certain time, banish their offspring, disown their acquaintance, seem to have even no knowledge of the objects which so lately engrossed the attention of their minds, and occupied the industry and labour of their bodies. This change in different animals takes place at different distances of time from the birth; but the time always corresponds with the ability of the young animal to maintain itself, never anticipates it. In the sparrow tribe, when it is perceived that the young brood can fly and shift for themselves, then the parents forsake them for ever; and, though they continue to live together, pay them no more attention than they do to other birds in the same flock.* I believe the same thing is true of all gregarious quadrupeds.[5]

In this part of the case the variety of resources, expedients, and materials which animals of the same species are said to have recourse to under different circumstances, and when differently supplied, makes nothing against the doctrine of instincts. The thing which we want to account for is the propensity. The propensity being there, it is probable enough that it may put the animal upon different actions according to different exigencies. And this adaptation of resources may look like the effect of art and consideration rather than of instinct; but still the propensity is instinctive. For instance, suppose what is related of the woodpecker to be true, that in Europe she deposites her eggs in cavities which she scoops out in the trunks of soft or decayed trees, and in which cav-

* Goldsmith's Nat. Hist., vol. iv., p. 244.

[5] In the natural and instinctive feelings of man, as contradistinguished from those which have been modified by reason, something of the same kind may be observed. The mutual relation of protection and dependance, produced by power and weakness, is of this description. A helpless infant excites much stronger sympathy in the mother than the child that can shift for itself; and hence the partiality, accompanied by blindness to defects, which most parents entertain towards children whose natural deficiency, whether bodily or mental, throws them on their care long after the season of infancy.

ities the eggs lie concealed from the eye, and in some sort safe from the hand of man; but that, in the forests of Guinea and the Brazils, which man seldom frequents, the same bird hangs her nest on the twigs of tall trees, thereby placing them out of the reach of *monkeys* and *snakes*, *i. e.*, that in each situation she prepares against the danger which she has most occasion to apprehend. Suppose, I say, this to be true, and to be alleged, on the part of the bird that builds these nests, as evidence of a reasoning and distinguishing precaution: still the question returns, whence the propensity to build at all?

Nor does parental affection accompany generation by any universal law of animal organization, if such a thing were intelligible. Some animals cherish their progeny with the most ardent fondness and the most assiduous attention; others entirely neglect them; and this distinction always meets the constitution of the young animal with respect to its wants and capacities. In many, the parental care extends to the young animal; in others, as in all oviparous fish, it is confined to the egg, and even as to that, to the disposal of it in its proper element. Also, as there is generation without parental affection, so is there parental instinct, or what exactly resembles it, without generation. In the bee tribe, the grub is nurtured neither by the father nor the mother, but by the neutral bee. Probably the case is the same with ants.

I am not ignorant of the theory which resolves instinct into sensation; which asserts, that what appears to have a view and relation to the future, is the result only of the present disposition of the animal's body, and of pleasure or pain experienced *at the time*. Thus the incubation of eggs is accounted for by the pleasure which the bird is supposed to receive from the pressure of the smooth convex surface of the shells against the abdomen, or by the relief which the mild temperature of the egg may afford to the heat of the lower part of the body, which is observed at this time to be increased beyond its usual state. This present gratification is the only motive with the hen for sit-

ting upon her nest; the hatching of the chickens is, with respect to her, an accidental consequence. The affection of viviparous animals for their young is in like manner solved by the relief, and, perhaps, the pleasure which they receive from giving suck. The young animal's seeking, in so many instances, the teat of its dam, is explained from its sense of smell, which is attracted by the odour of milk. The salmon's urging its way up the stream of fresh-water rivers is attributed to some gratification or refreshment which, in this particular state of the fish's body, she receives from the change of element. Now of this theory it may be said,

First, that of the cases which require solution, there are few to which it can be applied with tolerable probability; that there are none to which it can be applied without strong objections, furnished by the circumstances of the case. The attention of the cow to its calf, and of the ewe to its lamb, appear to be prior to their sucking. The attraction of the calf or lamb to the teat of the dam is not explained by simply referring it to the sense of smell. What made the scent of milk so agreeable to the lamb that it should follow it up with its nose, or seek with its mouth the place from which it proceeded? No observation, no experience, no argument could teach the new-dropped animal that the substance from which the scent issued was the material of its food. It had never tasted milk before its birth. None of the animals which are not designed for that nourishment ever offer to suck or to seek out any such food. What is the conclusion, but that the sugescent parts of animals are fitted for their use, and the knowledge of that use put into them?

We assert, secondly, that, even as to the cases in which the hypothesis has the fairest claim to consideration, it does not at all lessen the force of the argument for intention and design. The doctrine of instinct is that of appetencies, *superadded* to the constitution of an animal, for the effectuating of a purpose beneficial to the species. The above-stated so-

lution would derive these appetencies from organization; but, then, this organization is not less specifically, not less precisely, and, therefore, not less evidently adapted to the same ends, than the appetencies themselves would be upon the old hypothesis. In this way of considering the subject, sensation supplies the place of foresight: but this is the effect of contrivance on the part of the Creator. Let it be allowed, for example, that the hen is induced to brood upon her eggs by the enjoyment or relief which, in the heated state of her abdomen, she experiences from the pressure of round, smooth surfaces, or from the application of a temperate warmth. How comes this extraordinary heat or itching, or call it what you will, which you suppose to be the cause of the bird's inclination, to be felt just at the time when the inclination itself is wanted: when it tallies so exactly with the internal constitution of the egg, and with the help which that constitution requires in order to bring it to maturity? In my opinion, this solution, if it be accepted as to the fact, ought to increase, rather than otherwise, our admiration of the contrivance.[6] A gardener, lighting up his stoves just when

[6] Whether we regard the argument of existence or of attributes, the truth here glanced at is of extreme importance, and it pervades the whole of Natural Theology. When skeptics think they have destroyed one reason for believing in the skill or in the goodness of the Deity, by an explanation of the means used for producing some given effect, they only remove our admiration and our gratitude from one point to another, and often augment both the one and the other. Suppose it were discovered, contrary to all probability, that the bee* makes the angles of 109° 28′ and 70°

* Reference is made here to the admirable architecture of this little insect, in which we find it giving precisely such a shape to its cell, as respects both the inclination of its sides, and of the three planes which unite to form the top and bottom, as will best enable it to economize room, material, and labour, and yet secure strength. How to accomplish this would, until lately, have surpassed the skill of the profoundest human mathematician. The problem is one of the most difficult in that branch of the higher geometry which treats of *maxima* and *minima*, and, having been suggested by the celebrated Reaumur, was solved by a skilful application of the fluxional calculus.—*Am. Ed.*

he wants to force his fruit, and when his trees require the heat, gives not a more certain evidence of design. So, again, when a male and female sparrow come together, they do not meet to confer upon the expediency of perpetuating their species. As an abstract proposition, they care not the value of a barleycorn whether the species be perpetuated or not: they follow their sensations, and all those consequences ensue which the wisest counsels could have dictated, which the most solicitous care of futurity, which the most anxious care for the sparrow-world could have produced. But how do these consequences ensue? The sensations, and the constitution upon which they depend, are as manifestly directed to the purpose which we see fulfilled by them; and the train of intermediate effects as manifestly laid and planned with a view to that purpose: that is to say, design is as

32′ by means of some bodily conformation which secures this result; some form of its own parts answering to those angles, if such a thing can be conceived; the wonder is only removed from the working of the insect without a tool, to its using a tool provided for it by the intelligence which had solved the problem of maxima and minima, whence this conformation is a corollary. Again: the loss of one sense, as the sight, quickens our perceptions through the organs of those senses which remain, as touch and hearing. It is most probable that this effect is produced by the influence of habit, and has no direct connexion with the loss sustained. But habit might have had no such effect, and it might have blunted instead of sharpening; its effect tends to lessen the evil of the loss sustained; and it produces this advantage just as much as if the compensation had been the direct and immediate consequence of that loss. We are not here arguing the question of evil: that will be treated of hereafter; and it is common to both suppositions, both to the case of immediate and of mediate compensation. Again: suppose, in generalizing, we could resolve all intellectual phenomena into some one principle, as association; all moral into some other, as habit; all physical into some third, as gravitation; nay, suppose the doctrines of some materialists to prevail, and that all mental and all physical phenomena were resolvable into the operations of some subtile fluid, this would surely not weaken the arguments for the unity of the Deity, if, indeed, it did not rather strengthen them; it would in no degree detract from our conviction of his skill, nor even of the variety of its operations; and it would leave the argument as to goodness exactly where it stood before.

completely evinced by the phenomena, as it would be even if we suppose the operations to begin or to be carried on, from what some will allow to be alone properly called instincts, that is, from desires directed to a future end, and having no accomplishment or gratification distinct from the attainment of that end.

In a word, I should say to the patrons of this opinion, Be it so: be it that those actions of animals which we refer to instinct are not gone about with any view to their consequences, but that they are attended in the animal with a present gratification, and are pursued for the sake of that gratification alone; what does all this prove but that the *prospection*, which must be somewhere, is not in the animal, but in the Creator?

In treating of the parental affection in brutes, our business lies rather with the origin of the principle than with the effects and expressions of it. Writers recount these with pleasure and admiration. The conduct of many kinds of animals towards their young has escaped no observer, no historian of nature. "How will they caress them," says Derham, "with their affectionate notes; lull and quiet them with their tender parental voice; put food into their mouths; cherish and keep them warm; teach them to pick, and eat, and gather food for themselves; and, in a word, perform the part of so many nurses, deputed by the Sovereign Lord and Preserver of the world to help such young and shiftless creatures!" Neither ought it, under this head, to be forgotten, how much the instinct *costs* the animal which feels it; how much a bird, for example, gives up by sitting upon her nest; how repugnant it is to her organization, her habits, and her pleasures. An animal, formed for liberty, submits to confinement in the very season when everything invites her abroad: what is more, an animal delighting in motion, made for motion, all whose motions are so easy and so free, hardly a moment, at other times, at rest, is, for many hours of many days together, fixed to her nest, as close as if her limbs were tied down by pins and wires. For my part

I never see a bird in that situation but I recognise an invisible hand, detaining the contented prisoner from her fields and groves for the purpose, as the event proves, the most worthy of the sacrifice, the most important, the most beneficial.

But the loss of liberty is not the whole of what the procreant bird suffers. Harvey tells us that he has often found the female wasted to skin and bone by sitting upon her eggs.

One observation more, and I will dismiss the subject. The *pairing* of birds and the *non-pairing* of beasts forms a distinction between the two classes, which shows that the conjugal instinct is modified with a reference to utility founded on the condition of the offspring. In quadrupeds, the young animal draws its nutriment from the body of the dam. The male parent neither does, nor can contribute any part to its sustentation. In the winged race, the young bird is supplied by an importation of food, to procure and bring home which, in a sufficient quantity for the demand of a numerous brood, requires the industry of both parents. In this difference we see a reason for the vagrant instinct of the quadruped, and for the faithful love of the feathered mate.[7]

CHAPTER XIX.

OF INSECTS.

We are not writing a system of natural history; therefore we have not attended to the classes into

[7] This argument might be extended by reference to the human species. Here, again, the sexual instinct leads to *pairing*, and the pairing is intended to be permanent. The reason is obvious. The young of the human race are dependant for support upon the parent much longer than the young of any other animal; and this support, as well as their intellectual and moral culture, requires the joint efforts of both parents.—*Am. Ed.*

which the subjects of that science are distributed. What we had to observe concerning different species of animals, fell easily, for the most part, within the divisions which the course of our argument led us to adopt. There remain, however, some remarks upon the *insect* tribe, which could not properly be introduced under any other of these heads; and which, therefore, we have collected into a chapter by themselves.

The structure and the use of the parts of insects are less understood than that of quadrupeds and birds, not only by reason of their minuteness or the minuteness of their parts (for that minuteness we can, in some measure, follow with glasses), but also by reason of the remoteness of their manners and modes of life from those of larger animals. For instance: Insects, under all their varieties of form, are endowed with *antennæ*,[8] which is the name given to those long feelers that rise from each side of the head: but to what common use or want of the insect kind a provision so universal is subservient, has not yet been ascertained; and it has not been ascertained, because it admits not of a clear or very probable comparison with any organs which we possess ourselves, or with the organs of animals which resemble ourselves in their functions and faculties, or with which we are better acquainted than we are with insects. We want a ground of analogy. This difficul-

[8] The most scientific entomologists consider the antennæ of insects to be organs of hearing; this is the opinion of those who have minutely examined their structure; whereas very many entomologists contend that the antennæ are organs of feeling, observing that many insects are constantly touching surrounding objects with them, such as the bee tribe, ichneumonidæ, &c. The argument used against the latter opinion is, that although many insects do undoubtedly touch surrounding objects with their antennæ, yet many scrupulously avoid so doing, such as the butterfly and moth tribe, the Lamellicorn beetles, &c. When, however, we are asked the question, What is hearing as distinguished from feeling? we find it difficult to draw any line. Are they not mere modifications of the same thing? and, as the antennæ of insects are so exceedingly variable in form, may they not be used as organs of touch in some, and of hearing in others?

ty stands in our way as to some particulars in the insect constitution, which we might wish to be acquainted with. Nevertheless, there are many contrivances in the bodies of insects neither dubious in their use nor obscure in their structure, and most properly mechanical. These form parts of *our* argument.

I. The *elytra*, or scaly wings of the genus of scarabæus or beetle, furnish an example of this kind. The true wing of the animal is a light, transparent membrane, finer than the finest gauze, and not unlike it. It is also, when expanded, in proportion to the size of the animal, very large. In order to protect this delicate structure, and, perhaps, to preserve it in a due state of suppleness and humidity, a strong, hard case is given to it, in the shape of the horny wing which we call the elytron. When the animal is at rest, the gauze wings lie folded up under this impenetrable shield. When the beetle prepares for flying, he raises the integument, and spreads out his thin membrane to the air. And it cannot be observed without admiration, what a tissue of cordage, *i. e.*, of muscular tendons, must run in various and complicated, but determinate directions, along this fine surface, in order to enable the animal either to gather it up into a certain precise form whenever it desires to place its wings under the shelter which nature hath given to them, or to expand again their folds when wanted for action.

In some insects the elytra cover the whole body;[9] in others, half; in others only a small part of it;[10] but in all[11] they completely hide and cover the true wings. Also,

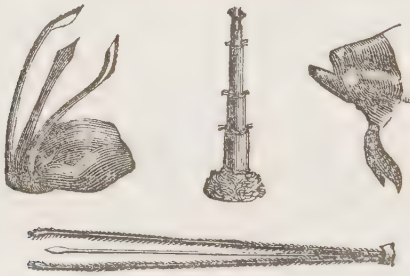
[9] From this circumstance beetles (the tribe of insects to which the above description applies) have received the name of *Coleoptera*, from two Greek words signifying *sheath* and *wing*.

[10] A tribe of insects called the *Brachelytra* (or *Staphylinus* of Linnæus) possess wing cases of this description.

[11] There are exceptions. In the genera *Molorchus*, *Sitaris* (and others might be enumerated among the beetle tribe), the wing cases are small and narrow, and leave the wings exposed. The species of the genus *Molorchus*, however, do not require such pro-

Many or most of the beetle species lodge in holes in the earth, environed by hard, rough substances, and have frequently to squeeze their way through narrow passages; in which situation wings so tender and so large could scarcely have escaped injury, without both a firm covering to defend them, and the capacity of collecting themselves up under its protection.[12]

II. Another contrivance, equally mechanical, and equally clear, is the *awl* or borer fixed at the tails of various species of flies; and with which they pierce, in some cases, plants; in others, wood; in others,[13]



tection for their wings, since they live in flowers. The habits of the *Sitaris* are not so well known; they are said to live in the nests of certain species of bees.

In the earwig the elytra do not entirely cover the wings; but the portion of the wing exposed is of hornlike substance, like the elytra, while the remaining part of the wing is extremely delicate.

[12] A tribe of beetles coming under the generic name of *Hister*, forms a good illustration of this mode of existence: in these insects the elytra are remarkably hard.

The species of the genus *Hister* possess remarkable analogical resemblances to tortoises, which have somewhat similar habits; like them, they are exceedingly hard, of an oval shape, and have the power of retracting the head beneath a horny covering; they are slothful, and very strong, and burrow in the ground by means of their fore legs.

A great analogical resemblance also exists between an insect called the mole-cricket and the mole, their habits also being similar.

[13] Almost every caterpillar (perhaps without exception) has its

the skin and flesh of animals; in others, the coat of the chrysalis of insects of a different species from their own; and in others, even lime, mortar, and stone.[14] I need not add that, having pierced the substance, they deposite their eggs in the hole. The descriptions which naturalists give of this organ are such as the following: It is a sharp-pointed instrument, which, in its inactive state, lies concealed in the extremity of the abdomen, and which the animal draws out at pleasure, for the purpose of making a puncture in the leaves, stem, or bark of the particular plant which is suited to the nourishment of its young. In a sheath, which divides and opens whenever the organ is used, there is enclosed a compact, solid, dentated stem, along which runs a *gutter* or *groove*, by which groove, after the penetration is effected, the egg, assisted in some cases by a peristaltic motion, passes to its destined lodgment. In the œstrum or gadfly, the wimble[15] *draws out* like the pieces of a spy-glass: the last piece is armed with three hooks, and

peculiar parasites among the ichneumonidæ, a different tribe of insects: the same ichneumon almost invariably choosing the same caterpillar to deposite its eggs upon or in; and as the situations in which different caterpillars feed are very various, so is the structure of their parasites. The ichneumons which infest internal feeding caterpillars (*i. e.*, such as feed in the trunk of a tree or the stem of a plant) are furnished with long ovipostors, to enable them to reach the caterpillar through some hole or chink where they themselves cannot get.

Even the ichneumons are not free from parasites. There are instances where four or five different parasitical insects have been found in the same chrysalis (as that of the *Trichiosoma leucorum*, a sawfly), each one feeding upon the other. Thus several larvæ of an ichneumon may be found feeding upon the inside of a chrysalis; and, when these larvæ turn into pupæ or chrysalides, some of the chalcididæ, a different tribe of flies, will feed upon them, and even some of the last may in their turn be eaten up.

[14] There is not any accredited instance of any insects perforating so hard a substance as stone with the "awl or borer" fixed at the tail. This instrument, technically called ovipositor, is excessively variable in its structure, being scarcely alike in any two species: the description given will answer for that of the sawfly (*Tentredo*).

[15] Whimble or ovipositor.

is able to bore through the hide of an ox. Can anything more be necessary to display the mechanism than to relate this fact?

III. The *stings*[16] of insects, though for a different purpose, are, in their structure, not unlike the piercer. The sharpness to which the point in all of them is wrought; the temper and firmness of the substance of which it is composed; the strength of the muscles by which it is darted out, compared with the smallness and weakness of the insect, and with the soft and friable texture of the rest of the body, are properties of the sting to be noticed, and not a little to be admired. The sting of a *bee* will pierce through a goatskin glove. It penetrates the human flesh more readily than the finest point of a needle. The *action* of the sting affords an example of the union of chymistry and mechanism, such as, if it be not a proof of contrivance, nothing is. First, as to the chymistry: how highly concentrated must be the *venom* which, in so small a quantity, can produce such powerful effects! And in the bee we may observe that this venom is made from *honey*, the only food of the insect, but the last material from which I should have expected that an exalted poison could, by any process of digestion whatsoever, have been prepared. In the next place, with respect to the mechanism, the sting is not a simple, but a compound instrument. The visible sting, though drawn to a point exquisitely sharp, is in strictness only a sheath; for near to the extremity may be perceived by the microscope two minute orifices, from which orifices, in the act of stinging, and, as it should seem, after the point of the main sting has buried itself in the flesh, are launched out two subtile rays, which may be called the true or proper stings, as being those through which the poison is infused into the puncture already made by the exterior sting. I have said that chymistry and mechanism are here *united:* by which observation I meant, that all this machinery would have been useless, *telum*

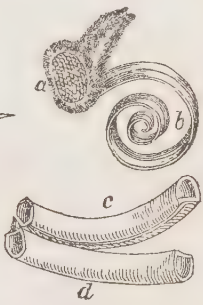
[16] The stings of insects are also used as ovipositors.

imbelle, if a supply of poison, intense in quality, in proportion to the smallness of the drop, had not been furnished to it by the chymical elaboration which was carried on in the insect's body; and that, on the other hand, the poison, the result of this process, could not have attained its effect or reached its enemy if, when it was collected at the extremity of the abdomen, it had not found there a machinery fitted to conduct it to the external situations in which it was to operate, *viz.*, an awl to bore a hole and a syringe to inject the fluid. Yet these attributes, though combined in their action, are independent in their origin. The venom does not breed the sting, nor does the sting concoct the venom.

IV. The *proboscis*,[17] with which many insects are en-

Fig. 1.

Fig. 2.



[17] The part called proboscis in the bee consists of a central stalk or tongue, *a* (Fig. 1), and four lateral pieces or jaws, two of which spring from the base, and two have their origin near the middle. The apical half of the stalk is soft and flexible, rather flat, and covered with minute hairs: it is chiefly this part of the proboscis which is used in collecting honey. Honey is not sucked up, as is generally supposed, but licked up, and then conveyed to the œsophagus. The four lateral pieces, when closed, form a sheath to protect the tongue, and other parts of the central stalk. Fig. 2 represents the profile of a butterfly's head; *a* is the compound eye, and *b* the proboscis partially unfolded; *c* and *d* show portions of the tubes forming the proboscis highly magnified.

dowed, comes next in order to be considered. It is a tube attached to the head of the animal; in the bee it is composed of two pieces, connected by a joint: for, if it were constantly extended, it would be too much exposed to accidental injuries; therefore, in its indolent state, it is doubled up by means of the joint, and in that position lies secure under a scaly penthouse.[18] In many species of the butterfly, the proboscis, when not in use, is coiled up like a watch-spring. In the same bee, the proboscis serves the office of the mouth, the insect having no other;[19] and how much better adapted it is than a mouth would be for the collecting of the proper nourishment of the animal, is sufficiently evident. The food of the bee is the nectar of flowers; a drop of sirup, lodged deep in the bottom of the corollæ, in the recesses of the petals, or down the neck of a monopetalous glove. Into these cells the bee thrusts its long narrow pump, through the cavity of which it sucks[20] up this precious fluid, inaccessible to every other approach. It is observable also, that the plant is not the worse[21] for what the bee does to it. The harm-

[18] There is an indentation in the under side of the head to receive the proboscis when folded up.

[19] A bee has the same number of parts to its mouth as any other insect; the only difference between that of a bee and a beetle is, that some of the parts are more developed in the former; *viz.*, the labium, tongue, and maxillæ.

[20] See Note 17. It might be more correct to say *lick up*, for there is no tube.

[21] Bees are essential to the fructification of many sorts of plants, for it is by them that the farina is carried from the male to the female flowers; and as some flowers yield a much greater quantity of honey than others, it might perhaps be imagined that those yielding little, and yet depending upon the bees for their fructification, might often be barren. No such defects, however, are to be found; the structure of the proboscis varies considerably in different species of bees, so that all bees cannot collect indiscriminately from any honey-yielding plant. One great tribe of bees (the *apidæ*) collect their honey for the most part from bell-shaped flowers, such as the blind-nettle, &c.; their long proboscis enabling them to reach the bottom of the bells. Another tribe, having the proboscis short, are obliged to collect from flowers of a different shape. There is yet another circumstance which leads the differ-

less plunderer rifles the sweets, but leaves the flower uninjured. The ringlets of which the proboscis of the bee is composed, the muscles by which it is extended and contracted, form so many microscopical wonders. The agility, also, with which it is moved, can hardly fail to excite admiration. But it is enough for our purpose to observe, in general, the suitableness of the structure to the use of the means to the end, and especially the wisdom by which nature has departed from its most general analogy (for animals being furnished with mouths are such), when the purpose could be better answered by the deviation.

In some insects the proboscis, or tongue, or trunk, is shut up in a sharp-pointed sheath, which sheath,[22] being of a much firmer texture than the proboscis itself, as well as sharpened at the point, pierces the substance which contains the food, and then *opens within the wound*, to allow the enclosed tube through which the juice is extracted to perform its office. Can any mechanism be plainer than this is, or surpass this?

V. The *metamorphosis* of insects from grubs into moths and flies is an astonishing process. A hairy caterpillar is transformed into a butterfly. Observe the change. We have four beautiful wings where

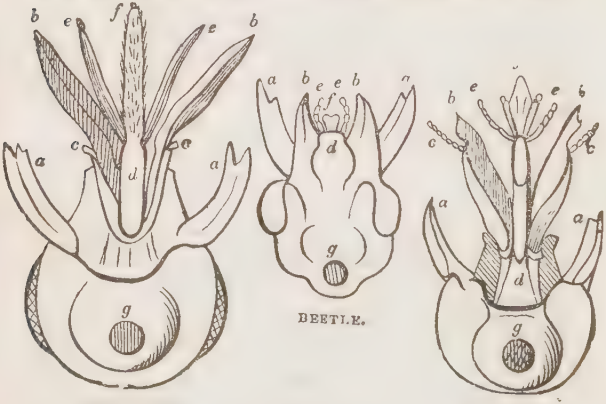
ent sorts of bees to visit a variety of flowers: viz., that they do not feed their larvæ on the same substance. If we examine the cells of some (the *andrænidæ*), we find that the food stored up for the young consists of a ball of farina, which has scarcely any admixture of honey; these bees would naturally seek those flowers which yield the most farina; whereas, in others (the *apidæ*), honey with very little farina is stored up for the young.

[22] The mouth of the common flea (*Pulex irritans*) is of this nature: it is composed of seven pieces, a pair of *mandibles*, a pair of *maxillæ*, two *palpi* or feelers, and a *tongue*. The uses of these pieces appear to be as follows: the *mandibles*, which are short, strong, and sharp, are to cut through the outer skin; the *maxillæ*, which are long and shaped like lancets, are to pierce still deeper, so as to cause bleeding: the *tongue* is then used to lick and convey the blood to the œsophagus; and the *palpi* are to direct these operations, conveying information to the animal by feeling or touch. These same seven parts (forming the mouth, and technically called *trophi*) are to be found in almost all insects, but constructed in different ways to suit the various habits of the species.

there were none before; a tubular proboscis in the place of a mouth with jaws and teeth;[23] six long legs

[23] The mouth of the caterpillar, or larva state of insects, has, in the greater portion of the species, the same number of parts as that of the perfect insect. In the pupa state some of these parts become nearly or quite obliterated, while others are much more developed to suit the habits of the animal in its next or perfect state of existence; and thus, of course, in some instances, where there is but little difference between the habits of the larvæ and those of the perfect insect, there is likewise but little difference in the structure of the mouth, as, for instance, in locusts, grasshoppers, and cockroaches.

In the butterfly tribe the maxillæ or under jaws of the caterpillar become in the perfect insect elongated into two tubes (see cut), which may be joined together at the pleasure of the animal by means of projecting ridges (furnished with a sort of hook somewhat like the laminæ of feathers), in such a way as to leave a



HUMBLE BEE. BEETLE. BEE.

a, *a*, mandibles; *b*, *b*, maxillæ; *c*, *c*, maxillary palpi; *d*, *d*, labium; *e*, *e*, labial palpi; *f*, tongue; *g*, neck.

third tube between the two. It is through the central tube that the nectar is pumped or sucked up; the two outer tubes Reaumur imagines are for the reception of air; if this be the case, it may possibly be that air which is discharged from the central tube to create the necessary vacuum. The mandibles, or upper jaws,

instead of fourteen feet. In another case we see a white, smooth, soft worm turned into a black, hard, crustaceous beetle with gauze wings. These, as I said, are astonishing processes, and must require, as it should seem, a proportionably artificial apparatus. The hypothesis which appears to me most probable is, that, in the grub, there exist at the same time three animals, one within another, all nourished by the same digestion, and by a communicating circulation, but in different stages of maturity.[24] The latest discoveries made by naturalists seem to favour this supposition. The insect, already equipped with wings, is descried under the membranes both of the worm and nymph. In some species the proboscis, the antennæ, the limbs, and wings of the fly have been observed to be folded up within the body of the cater-

and other parts conspicuous in the caterpillar, are to be found only in a rudimentary state in the butterfly; yet they do exist.

[24] The following observations do not exactly support the opinions of Dr. Paley. It is more probable that the parts which are to appear in the perfect insect do *not* exist in the larvæ, where there is not much difference between the larva and pupa, excepting at the time just previous to its becoming a pupa, at which time the larva is motionless and torpid. The caterpillar of a moth, when about to turn into a pupa, provides for the protection of the latter state, either by surrounding itself with a web, or by some other means. Soon after this is accomplished, the caterpillar becomes motionless, or nearly so; it can neither eat nor crawl. At this time, and *not before*, the parts of the pupa are forming within the skin of the caterpillar, which may be easily seen by dissection. When the difference between the larva and the perfect insect is great, this is always the case, and the pupa is passive; but, when the difference is not so considerable, the case is different. The larva of a grasshopper scarcely differs from the perfect insect it is to become, except in wanting wings; the pupa differs only in having rudimentary instead of perfect wings; it casts its skin; it is then the perfect insect, excepting that the wings are crippled, and these very rapidly expand. In this latter case it is seen that there is but little difference between the three stages, and the change from the caterpillar to the moth is very great, and takes place only during the torpid state of the former, which state is to allow of its taking place. In the case of the grasshopper, where the changes are but slight, we should imagine but little of this torpidity would be required; and such appears to be the case, for the pupæ of grasshoppers and allied insects are always as active as either the larva or perfect insect.

pillar, and with such nicety as to occupy a small space only under the two first wings. This being so, the outermost animal, which, besides its own proper character, serves as an integument to the other two, being the farthest advanced, dies, as we suppose, and drops off first. The second, the pupa or chrysalis, then offers itself to observation. This also, in its turn, dies; its dead and brittle husk also falls to pieces, and makes way for the appearance of the fly or moth. Now if this be the case, or, indeed, whatever explication be adopted, we have a prospective contrivance of the most curious kind; we have organizations *three deep*, yet a vascular system which supplies nutrition, growth, and life to all of them together.

VI. Almost all insects are oviparous. Nature keeps her butterflies, moths, and caterpillars locked up during the winter in their egg state; and we have to admire the various devices to which, if we may so speak, the same nature hath resorted for the *security* of the egg. Many insects enclose their eggs in a silken web; others cover them with a coat of hair torn from their own bodies; some glue them together; and others, like the moth of the silkworm, glue them to the leaves upon which they are deposited, that they may not be shaken off by the wind or washed away by rain. Some, again, make incisions into leaves, and hide an egg in each incision, while some envelop their eggs with a soft substance which forms the first aliment of the young animal; and some again make a hole in the earth, and, having stored it with a quantity of proper food, deposite their eggs in it. In all which we are to observe, that the expedient depends not so much upon the address of the animal as upon the physical resources of his constitution.

The art, also, with which the young insect is *coiled up* in the egg, presents, where it can be examined, a subject of great curiosity. The insect, furnished with all the members which it ought to have, is rolled up into a form which seems to contract it into the least possible space; by which contraction, notwithstanding

the smallness of the egg, it has room enough in its apartment and to spare. This folding of the limbs appears to me to indicate a special direction; for if it were merely the effect of compression, the collocation of the parts would be more various than it is. In the same species, I believe, it is always the same.

These observations belong to the whole insect tribe, or to a great part of them. Other observations are limited to fewer species, but not, perhaps, less important or satisfactory.

I. The organization in the abdomen of the *silkworm* or *spider*, whereby these insects form their *thread*, is as incontestably mechanical as a wire-drawer's mill. In the body of the silkworm are two bags, remark-

able for their form, position, and use. They wind round the intestine; when drawn out they are ten inches in length, though the animal itself be only two. Within these bags is collected a glue; and communicating with the bags are two paps or outlets, perforated, like a grater, by a number of small holes. The glue or gum, being passed through these minute apertures, forms hairs of almost imperceptible fineness; and these hairs, when joined, compose the silk which we wind off from the cone in which the silkworm has wrapped itself up: in the spider the web is formed from this thread. In both cases the extremity of the thread, by means of its adhesive quality, is first attached by the animal to some external hold; and the end being now fastened to a point, the insect, by turning round its body or by receding from that point, draws out the thread through the holes above described, by an operation, as hath been observed, exactly similar to the drawing of wire. The thread, like the wire, is formed by the hole through which it passes. In one respect there is a difference. The wire is the metal unaltered, except in figure. In

the animal process the nature of the substance is somewhat changed as well as the form; for, as it exists within the insect, it is a soft, clammy gum or glue. The thread acquires, it is probable, its firmness and tenacity from the action of the air upon its surface in the moment of exposure; and a thread so fine is almost all surface. This property, however, of the paste is part of the contrivance.

The mechanism itself consists of the bags or reservoirs into which the glue is collected, and of the external holes communicating with these bags; and the action of the machine is seen in the forming of a thread, as wire is formed, by forcing the material already prepared through holes of proper dimensions. The secretion is an act too subtile for our discernment, except as we perceive it by the produce. But one thing answers to another; the secretory glands to the quality and consistence required in the secreted substance, the bag to its reception. The outlets and orifices are constructed not merely for relieving the reservoirs of their burden, but for manufacturing the contents into a form and texture of great external use, or rather, indeed, of future necessity, to the life and functions of the insect.

II. Bees, under one character or other, have furnished every naturalist with a set of observations. I shall, in this place, confine myself to one; and that is the *relation* which obtains between the wax and the honey. No person who has inspected a beehive can forbear remarking how commodiously the honey is bestowed in the comb, and, among other advantages, how effectually the fermentation of the honey is prevented by distributing it into small cells. The fact is, that when the honey is separated from the comb and put into jars, it runs into fermentation with a much less degree of heat than what takes place in a hive. This may be reckoned a nicety; but, independently of any nicety in the matter, I would ask, what could the bee do with the honey if it had not the wax? how, at least, could it store it up for winter? The wax, therefore, answers a purpose with

respect to the honey, and the honey constitutes that purpose with respect to the wax. This is the relation between them. But the two substances, though together of the greatest use, and, without each other, of little, come from a different origin. The bee finds the honey, but makes the wax. The honey is lodged in the nectaria of flowers, and probably undergoes little alteration—is merely collected; whereas the wax is a ductile tenacious paste, made out of a dry powder,[25] not simply by kneading it with a liquid, but by a digestive process in the body of the bee. What account can be rendered of facts so circumstanced, but that the animal, being intended to feed upon honey, was, by a peculiar external configuration, enabled to procure it? That, moreover, wanting the honey when it could not be procured at all, it was farther endued with the no less necessary faculty of constructing repositories for its preservation? Which faculty, it is evident, must depend primarily upon the capacity of providing suitable materials. Two distinct functions go to make up the ability. First, the power in the bee, with respect to wax, of loading the farina of flowers upon its thighs. Microscopic observers speak of the spoon-shaped appendages with which the thighs of bees are beset for this very purpose; but, inasmuch as the art and will of the bee may be supposed to be concerned in this operation, there is, secondly, that which doth not rest in art or will, a digestive faculty, which converts the loose powder into a stiff substance. This is a just account of the honey and the honey-comb; and this account, through every part, carries a creative intelligence along with it.[26]

[25] The opinion of Huber, Hunter, and others, is, that wax is not made out of pollen, but from honey. Huber kept some bees confined, and fed them with honey only, and wax was secreted as usual. It is most likely that bees never eat farina, and that it is collected from the larvæ only. See article BEE, "Penny Cyclopædia."

[26] It has often been remarked, that Dr. Paley does not, either in this chapter or in that on instinct, state the most remarkable of all instincts, and of all the labours of insects, the formation of the cells by the bee, according to the strictest geometrical rules. The his

The *sting* also of the bee has this relation to the honey, that it is necessary for the protection of a treasure which invites so many robbers.

III. Our business is with mechanism. In the *panorpa* tribe of insects, there is a forceps in the tail of the male insect, with which he catches and holds the female. Are a pair of pincers more mechanical than this provision in its structure? or is any structure more clear and certain in its design?[27]

IV. St. Pierre tells us,* that in a fly with six feet (I do not remember that he describes the species), the pair next the head and the pair next the tail have brushes at their extremities, with which the fly dresses, as there may be occasion, the anterior or the posterior part of its body; but that the middle pair have no such brushes, the situation of these legs not admitting of the brushes, if they were there, being converted to the same use. This is a very exact mechanical distinction.[28]

V. If the reader, looking to our distributions of science, wish to contemplate the chymistry as well as the mechanism of nature, the insect creation will afford him an example. I refer to the light in the tail of a *glow-worm*. Two points seem to be agreed upon by naturalists concerning it: first, that it is phospho-

tory of this discovery, made (through Reaumur's suggestion) by Kœnig's application of the fluxional calculus, and by its result being found to tally with Maraldi's measurement, has been referred to in a previous note, and is well worthy of attention. Maclaurin solved the same problem afterward, by the help of plain geometry, with a truly felicitous skill. The angles actually made differ by about two minutes from those given by the calculus; but no one can doubt that subsequent discovery will explain this.

[27] In the genus *Trichius* (a tribe of beetles closely allied to the rose beetle) the males have the tibiæ of the middle pair of legs curved for the same purpose.

* See ante, p. 38.

[28] The stag beetle (*Lucanus cervus*) cleans its antennæ "by drawing them between the thigh of the fore leg and the under side of the thorax, in both of which parts a velvet-like patch of hair is to be observed, which is well adapted for such purpose." See this, and other peculiarities in the same insect, in the first Part of the Entomological Society's Transactions, in "The Journal of Proceedings," page 6.

ric; secondly, that its use is to attract the male insect. The only thing to be inquired after is the singularity, if any such there be, in the natural history of this animal, which should render a provision of this kind more necessary for it than for other insects. That singularity seems to be the difference which subsists between the male and the female, which difference is greater than what we find in any other species of animal whatever. The glow-worm is a female *caterpillar*, the male of which is a *fly*, lively, comparatively small, dissimilar to the female in appearance, probably also as distinguished from her in habits, pursuits, and manners, as he is unlike in form and external constitution. Here, then, is the adversity of the case. The caterpillar cannot meet her companion in the air. The winged rover disdains the ground. They might never, therefore, be brought together, did not this radiant torch direct the volatile mate to his sedentary female.[29]

In this example we also see the resources of art anticipated. One grand operation of chymistry is the making of phosphorus; and it was thought an ingenious device to make phosphoric matches supply the place of lighted tapers. Now this very thing is done in the body of the glow-worm. The phosphorus is not only made, but kindled, and caused to emit a steady and genial beam, for the purpose which is here stated, and which I believe to be the true one.[30]

[29] The female glow-worm undergoes the same transformations as all other insects, and its perfect state differs considerably from its larva or caterpillar state, though in both stages it emits the phosphoric light. Besides the ordinary sexual distinctions, the female glow-worm differs from the male only in being apterous; but apterous female insects are not unfrequent; thus many species of moths have no wings. The two circumstances of the sedentary habits of the female, and the males flying by night only, seems to show the use of the light. See the next note.

[30] There exists some controversy among naturalists as to the use of the glow-worm's light. This doubt has been chiefly raised by the observation that the insect is luminous, though in an imperfect degree, when in the state in which it cannot propagate, as mentioned in the last note; and that other insects are attracted by light as well as the male glow-worm. The preponderance of

VI. Nor is the last the only instance that entomology affords in which our discoveries, or, rather, our projects, turn out to be imitations of nature. Some years ago, a plan was suggested of producing propulsion by reaction in this way: by the force of a steam-engine, a stream of water was to be shot out of the stern of a boat, the impulse of which stream upon the water in the river was to push the boat itself forward; it is, in truth, the principle by which sky-rockets ascend in the air. Of the use or practicability of the plan I am not speaking; nor is it my concern to praise its ingenuity; but it is certainly a contrivance. Now, if naturalists are to be believed, it is exactly the device which nature has made use of for the motion of some species of aquatic insects. The larva of the *dragon-fly*, according to Adams, swims by ejecting water from its tail; is driven forward by the reaction of water in the pool upon the current issuing in a direction backward from its body

VII. Again: Europe has lately been surprised by the elevation of bodies in the air by means of a balloon. The discovery consisted in finding out a manageable substance, which was, bulk for bulk, lighter than air; and the application of the discovery was to make a body composed of this substance bear up, along with its own weight, some heavier body which was attached to it. This expedient, so new to us, proves to be no other than what the Author of nature has employed in the *gossamer spider*. We frequently see this spider's thread floating in the air, and extended from hedge to hedge, across a road or brook of four or five yards width. The animal which forms the thread has no wings wherewith to fly from one extremity to the other of this line, nor muscles to enable it to spring or dart to so great a distance: yet its Creator hath laid for it a path in the atmosphere; and after this manner. Though the animal itself be heavier than air, the thread which it spins from its bowels is

the argument is decidedly in favour of the supposition adopted by our author, and which is also the commonly received opinion.

specifically lighter. This is its *balloon*. The spider, left to itself, would drop to the ground; but, being tied to its thread, both are supported. We have here a very peculiar provision; and, to a contemplative eye, it is a gratifying spectacle to see this insect wafted on her thread, sustained by a levity not her own, and traversing regions which, if we examined only the body of the animal, might seem to have been forbidden to its nature.[31]

I must now crave the reader's permission to introduce into this place, for want of a better, an observation or two upon the tribe of animals, whether belonging to land or water, which are covered by *shells*.

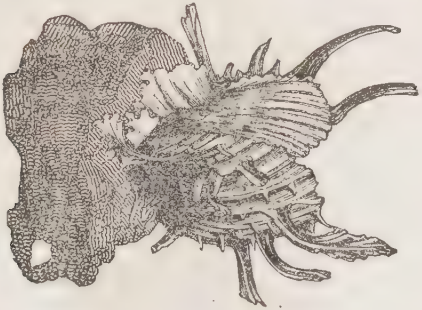
Helix aspersa of Müller, common garden snail; but the cut represents what is called a left-handed shell, and a rarity.

[31] It was at one time supposed that the spider could project its thread through the air at will in any direction, and, thus attaching it to different bodies, move from one to the other. The observations more accurately made of late years, show that this power is not possessed by the animal, but that it requires the aid of a current of air to direct the thread. This correction, however, of the former opinion, in no way weakens the force of the argument in the text.

I. The *shells* of *snails* are a wonderful, a mechanical, and, if one might so speak concerning the works of nature, an original contrivance. Other animals have their proper retreat, their hybernacula also, or winter-quarters, but the snail carries these about with him. He travels with his tent; and this tent, though, as was necessary, both light and thin, is completely impervious either to moisture or air. The young snail comes out of its egg with the shell upon its back; and the gradual enlargement which the shell receives is derived from the slime excreted by the animal's skin. Now the aptness of this excretion to the purpose, its property of hardening into a shell,[32] and the action, whatever it be, of the animal, whereby it avails itself of its gift, and of the constitution of its glands (to say nothing of the work being commenced before the animal is born), are things which can, with no probability, be referred to any other cause than to express design; and that not on the part of the animal alone, in which design, though it might build the house, it could not have supplied the material. The will of the animal could not determine the quality of the excretion. Add to which, that the shell of the snail, with its pillar and convolution, is a very artificial fabric; while a snail, as it should seem, is the most numb and unprovided of all artificers. In the midst of variety, there is likewise a regularity which could hardly be expected. In the same species of snail, the number of turns is usually, if not always, the same. The sealing up of the mouth of the shell by the snail is also well calculated for its warmth and security; but the cerate is not of the same substance with the shell.

[32] The shell is not merely a concretion of slime or mucus produced by the influence of the atmosphere. It is more properly the result of a regular secretion from the body of the animal of a substance combined of earthy and gelatinous matter. Delicate experiments have been made by steeping shells in diluted nitric acid, by which it is shown that the carbonate of lime is the earthy material of shells, and that, when that earth is dissolved, a gelatinous substance of the form of the shell remains.—*Am. Ed.*

II. Much of what has been observed of snails belongs to *shellfish* and their *shells*, particularly to those of the univalve kind; with the addition of two re-



Spondylus—prickly oyster.

marks, one of which is upon the great strength and hardness of most of these shells. I do not know whether, the weight being given, art can produce so strong a case as are some of these shells; which defensive strength suits well with the life of an animal that has often to sustain the dangers of a stormy ele-

Ostrea crista galli of Lamarck, *Mytilus crista galli* of Linnæus—the cock's-comb oyster.

ment and a rocky bottom, as well as the attacks of voracious fish. The other remark is upon the property, in the animal excretion, not only of congealing, but of congealing, or, as a builder would call it, *setting*, in water, and into a cretaceous substance, firm and hard. This property is much more extraordinary, and, chymically speaking, more specific, than that of hardening in the air, which may be reckoned a kind of exsiccation, like the drying of clay into bricks.

Cardium cardissa—Venus's heart cockle.

III. In the *bivalve* order of shellfish, cockles, mussels, oysters, &c., what contrivance can be so simple or so clear as the insertion, at the back, of a tough tendinous substance, that becomes at once the ligament which binds the two shells together, and the *hinge* upon which they open and shut?

IV. The shell of a lobster's tail, in its articulations and overlappings, represents the jointed part of a coat of mail; or, rather, which I believe to be the truth, a coat of mail is an imitation of a lobster's shell. The same end is to be answered by both; the same properties, therefore, are required in both; namely, hardness and flexibility; a covering which may guard the part without obstructing its motion. For this double purpose, the art of man, expressly exercised upon the subject, has not been able to devise anything better than what nature presents to his observation. Is not this, therefore, mechanism, which

the mechanic, having a similar purpose in view, adopts? Is the structure of a coat of mail to be referred to art? Is the same structure of the lobster, conducing to the same use, to be referred to anything less than art?

Some who may acknowledge the imitation, and assent to the inference which we draw from it in the instance before us, may be disposed, possibly, to ask, why such imitations are not more frequent than they are, if it be true, as we allege, that the same principle of intelligence, design, and mechanical contrivance was exerted in the formation of natural bodies as we employ in the making of the various instruments by which our purposes are served? The answers to this question are, first, that it seldom happens that precisely the same purpose, and no other, is pursued in any work which we compare of nature and of art; secondly, that it still more seldom happens that we *can* imitate nature if we would. Our materials and our workmanship are equally deficient. Springs and wires, and cork and leather, produce a poor substitute for an arm or a hand. In the example which we have selected, I mean a lobster's shell compared with a coat of mail, these difficulties stand less in the way than in almost any other that can be assigned; and the consequence is, as we have seen, that art gladly borrows from nature her contrivance, and imitates it closely.

But to return to insects. I think it is in this class of animals, above all others, especially when we take in the multitude of species which the microscope discovers, that we are struck with what Cicero has called "the *insatiable* variety of nature." There are said to be six thousand species of flies; seven hundred and sixty butterflies; each different from all the rest (St. Pierre).[33] The same writer tells us,

[33] There are collections of insects in this country (Great Britain) which, in all probability, contain forty thousand species.

from his own observation, that thirty-seven species of winged insects, with distinctions well expressed, visited a single strawberry-plant in the course of three weeks.* Ray observed, within the compass of a mile or two of his house, two hundred kinds of butterflies,[34] nocturnal and diurnal. He likewise asserts, but, I think, without any grounds of exact computation, that the number of species of insects, reckoning all sorts of them, may not be short of ten thousand.† And in this vast variety of animal forms (for the observation is not confined to insects, though more applicable perhaps to them than to any other class), we are sometimes led to take notice of the different methods, or, rather, of the studiously diversified methods, by which one and the same purpose is attained. In the article of breathing, for example, which was to be provided for in some way or other, besides the ordinary varieties of lungs, gills, and breathing-holes (for insects in general respire, not by the mouth, but through holes in the sides), the nymphæ of gnats have an apparatus to raise their *backs* to the top of the water, and so take breath. The hydrocanthari do the like by thrusting their *tails* out of the water.‡ The maggot of the eruca labra has a long tail, one part sheathed within another (but which it can draw out at pleasure), with a starry tuft at the end, by which *tuft*, when expanded upon the surface, the insect both supports itself in the water, and draws in the air which is necessary. In the article of natural clothing, we have the skins of animals invested with scales, hair, feathers, mucus,

The number of species in existence may fairly be reckoned at sixty or eighty thousand. Mr. Stephens, in his catalogue of British insects, enumerates ten thousand, since the publication of which many new species have been discovered. We are now speaking of true insects, animals having six legs, &c., and not including crabs, spiders, scorpions, and others, which *have been* classed with insects.

* Vol. i., p. 3.

[34] Ray must mean butterflies and *moths;* we have not one hundred species of butterflies in this country; and, besides, no butterflies are "nocturnal."

† Wisd. of God, p. 23 ‡ Derham, p. 7.

froth, or itself turned into a shell or crust. In the no less necessary article of offence and defence, we have teeth, talons, beaks, horns, stings, prickles, with (the most singular expedient for the same purpose) the power of giving the electric shock, and, as is credibly related of some animals, of driving away their pursuers by an intolerable fœtor, or of blackening the water through which they are pursued. The consideration of these appearances might induce us to believe that *variety* itself, distinct from every other reason, was a motive in the mind of the Creator, or with the agents of his will.

To this great variety in organized life the Deity has given, or perhaps there arises out of it, a corresponding variety of animal *appetites*. For the final cause of this we have not far to seek. Did all animals covet the same element, retreat, or food, it is evident how much fewer could be supplied and accommodated than what at present live conveniently together, and find a plentiful subsistence. What one nature rejects, another delights in. Food which is nauseous to one tribe of animals, becomes, by that very property which makes it nauseous, an alluring dainty to another tribe. Carrion is a treat to dogs, ravens, vultures, fish.[35] The exhalations of corrupted substances attract flies by crowds. Maggots revel in putrefaction.[36]

[35] Very many insects subsist entirely upon carrion, both in the larva and imago state, and in hot weather must be highly serviceable in removing such noxious substances. In this point of view the maggots of flies are exceedingly useful; a carcass becoming speedily threaded in every direction by them, is soon either devoured or wasted.

[36] The most remarkable circumstance relative to instinct, as well as to the habits of insects, the architecture of the bee, has been observed upon in a former note. The manufacture of the wasp perhaps comes next, and is to the chymistry what the former is to the mathematics of instinct. It furnishes, too, one of the most striking instances of the discoveries of man having been anticipated by the lower animals; and is another remarkable proof how many more might have been made by closely attending to their habits, perhaps a more remarkable proof than those referred to in the text of this chapter, and hinted at in chapter

CHAPTER XX.

OF PLANTS.

I THINK a designed and studied mechanism to be in general more evident in animals than in *plants;* and it is unnecessary to dwell upon a weaker argument where a stronger is at hand. There are, however, a few observations upon the vegetable kingdom which lie so directly in our way, that it would be improper to pass by them without notice.

viii., where the author is treating of the vertebræ and ribs. It is certain that some of the most material improvements in paper-making recently introduced, as the use of other substances besides rags, and the obtaining toughness by means of long fibres, had been known to the wasp from its first creation. Its whole process in making what is called *wasp-paper* is precisely that of the best paper-makers. It is another among the striking instances of the Divine agency through the operations of unreasoning animals; instances which fill the contemplative mind with the most profound and pleasing admiration, and dispose it to the enjoyment and the duty of heartfelt devotion.

The migration of birds is another subject full of instruction regarding the great questions connected with instinct. Observation seems at variance with the notion of the older birds teaching the yearlings; indeed, the two classes have been found not to travel together. But the agitation universally observed in birds of passage kept in cages, at the season of migration, proves clearly that no experience nor instruction will account for the change of place. See Mr. W. Herbert's excellent remarks on this instinct, and on the similar instincts respecting choice of food, which makes birds bred in a cage at once select their appointed food when shown them for the first time. White's Selbourne, edit. 1833, p. 41, *et seq.* The facts respecting carrier-pigeons and other animals finding their way through countries, in the knowledge of which they never could have been trained, belong to the same class.

The doctrine of conflicting instincts will be adverted to in the notes on the last chapter. Such apparent conflicts afford no ground whatever for the skeptical argument as to design; and they in no way strengthen the skeptical argument drawn, and inaccurately drawn, from other sources, respecting benevolence.

The one great intention of nature in the structure of plants seems to be the perfecting of the *seed*, and, what is part of the same intention, the preserving of it until it be *perfected*. This intention shows itself, in the first place, by the care which appears to be taken to protect and ripen, by every advantange which can be given to them of situation in the plant, those parts which most immediately contribute to fructification, viz., the antheræ, the stamina, and the stigmata. These parts are usually lodged in the centre, the recesses, or the labyrinths of the flower —during their tender and immature state are shut up in the stalk or sheltered in the bud—as soon as they have acquired firmness of texture sufficient to bear exposure, and are ready to perform the important office which is assigned to them, they are disclosed to the light and air by the bursting of the stem or the expansion of the petals; after which they have, in many cases, by the very form of the flower during its blow, the light and warmth reflected upon them from the concave side of the cup. What is called also the *sleep* of plants is the leaves or petals disposing themselves in such a manner as to shelter the young stems, buds, or fruit. They turn up or they fall down, according as this purpose renders either change of position requisite. In the growth of corn, whenever the plant begins to shoot, the two upper leaves of the stalk join together, embrace the ear, and protect it till the pulp has acquired a certain degree of consistency. In some water-plants the flowering and fecundation are carried on *within* the stem, which afterward opens to let loose the impregnated seed.* The *pea*, or papilionaceous tribe, enclose the parts of fructification within a beautiful folding of the internal blossom, sometimes called, from its shape, the boat or keel; itself also protected under a penthouse formed by the external petals. This structure is very artificial; and, what adds to the value of it, though it may diminish the curiosity, very general

* Philos. Transact., pt. ii., 1796, p. 502.

It has also this farther advantage (and it is an advantage strictly mechanical), that all the blossoms turn their *backs* to the wind whenever the gale blows strong enough to endanger the delicate parts upon which the seed depends. I have observed this a hundred times in a field of pease in blossom. It is an aptitude which results from the figure of the flower, and, as we have said, is strictly mechanical, as much so as the turning of a weather-board or tin cap upon the top of a chimney. Of the *poppy*, and of many similar species of flowers, the head while it is growing hangs down, a rigid curvature in the upper part of the stem giving to it that position; and in that

Papaver rhœas—Poppy.

position it is impenetrable by rain or moisture. When the head has acquired its size and is ready to open, the stalk *erects* itself for the purpose, as it should seem, of presenting the flower, and, with the flower, the instruments of fructification, to the genial influence of the sun's rays. This always struck me as a curious property, and specifically as well as originally provided for in the constitution of the plant; for if the stem be only bent by the weight of the head, how comes it to straighten itself when the head is the

heaviest? These instances show the attention of nature to this principal object, the safety and maturation of the parts upon which the seed depends.

In *trees*, especially in those which are natives of colder climates, this point is taken up earlier. Many of these trees (observe in particular the *ash* and the *horse-chestnut*) produce the embryos of the leaves and flowers in one year, and bring them to perfection the following. There is a winter, therefore, to be gotten over. Now what we are to remark is, how nature has prepared for the trials and severities of that season. These tender embryos are, in the first place, wrapped up with a compactness which no art can imitate; in which state they compose what we call the bud. This is not all. The bud itself is enclosed in scales, which scales are formed from the remains of past leaves and the rudiments of future ones.[37] Neither is this the whole. In the coldest climates, a third preservative is added, by the bud having a *coat* of gum or resin, which, being congealed, resists the strongest frosts. On the approach of warm weather, this gum is softened, and ceases to be a hinderance to the expansion of the leaves and flowers. All this care is part of that system of provisions which has for its object and consummation the production and perfecting of the seeds.

The SEEDS themselves are packed up in a *capsule*, a vessel composed of coats, which, compared with the rest of the flower, are strong and tough. From this vessel projects a tube, through which tube the farina, or some subtile fecundating effluvium that issues from

[37] This is not exactly true. Buds are not enclosed in scales formed from the remains of past leaves, except in a few rare instances, to which it cannot be supposed that the author refers; neither are they protected by what can be correctly called the rudiments of future leaves, or are only protected in part. The extensive scales of a bud, those in which the office of protection more especially resides, are rudimentary leaves, which are formed at the end of the season, when the force of development in the vegetable system is weak and imperfect; they do not become leaves another season, but are simply thrown off by the expansion of the leaves which unfold from within them.

it, is admitted to the seed. And here also occurs a mechanical variety, accommodated to the different circumstances under which the same purpose is to be accomplished. In flowers which are erect, the pistil is shorter than the stamina; and the pollen, shed from the antheræ into the cup of the flower, is caught in its descent by the head of the pistil, called the stigma. But how is this managed when the flowers hang down (as does the crown-imperial, for instance), and in which position the farina, in its fall, would be carried from the stigma, and not towards it? The relative length of the parts is now inverted. The pistil in these flowers is usually longer, instead of shorter, than the stamina, that its protruding summit may receive the pollen as it drops to the ground. In some cases (as in the *nigella*), where the shafts of the pistils or stiles are disproportionably long, they bend down their extremities upon the antheræ, that the necessary approximation may be effected. But (to pursue this great work in its progress) the impregnation, to which all this machinery relates, being completed, the other parts of the flower fade and drop off, while the *gravid seed-vessel*, on the contrary, proceeds to increase its bulk, always to a great, and in some species (in the gourd, for example, and melon) to a surprising comparative size; assuming in different plants an incalculable variety of forms, but all evidently conducing to the security of the seed. By virtue of this process, so necessary but so diversified, we have the seed at length in stone-fruits and nuts, encased in a strong shell, the shell itself enclosed in a pulp or husk, by which the seed within is, or has been, fed; or, more generally (as in grapes, oranges, and the numerous kinds of berries), plunged overhead in a glutinous syrup, contained within a skin or bladder: at other times (as in apples and pears) imbedded in the heart of a firm, fleshy substance, or (as in strawberries) pricked into the surface of a soft pulp.

These and many more varieties exist in what we call *fruits*.* In pulse, and grain, and grasses, in trees,

* From the conformation of fruits alone, one might be led, even

and shrubs, and flowers, the variety of the seed-vessels is incomputable. We have the seeds (as in the pea tribe) regularly disposed in parchment pods, which, though soft and membraneous, completely exclude the wet, even in the heaviest rains; the pod also not seldom (as in the bean) lined with a fine down; at other times (as in the senna) distended like a blown bladder: or we have the seed enveloped in wool (as in the cotton-plant), lodged (as in pines) between the hard and compact scales of a cone, or barricaded (as in the artichoke and thistle) with spikes and prickles; in mushrooms, placed under a penthouse; in ferns, within slits in the back part of the leaf: or (which is the most general organization of all) we

without experience, to suppose, that part of this provision was destined for the utilities of animals. As limited to the plant, the provision itself seems to go beyond its object. The flesh of an apple, the pulp of an orange, the meat of a plum, the fatness of the olive, appear to be *more* than sufficient for the nourishing of the seed or kernel. The event shows that this redundancy, if it be one, ministers to the support and gratification of animal natures; and when we observe a provision to be more than sufficient for one purpose, yet wanted for another purpose, it is not unfair to conclude that both purposes were contemplated together. It favours this view of the subject to remark, that fruits are not (which they might have been) ready altogether, but that they ripen in succession throughout a great part of the year; some in summer, some in autumn; that some require the slow maturation of the winter, and supply the spring; also that the coldest fruits grow in the hottest places. Cucumbers, pineapples, melons, are the natural produce of warm climates, and contribute greatly, by their coolness, to the refreshment of the inhabitants of those countries.

I will add to this note the following observation, communicated to me by Mr. Brinkley.

"The eatable part of the cherry or peach first serves the purposes of perfecting the seed or kernel, by means of vessels passing through the stone, and which are very visible in a peachstone. After the kernel is perfected, the stone becomes hard, and the vessels cease their functions. But the substance surrounding the stone is not then thrown away as useless. That which was before only an instrument for perfecting the kernel, now receives and retains to itself the whole of the sun's influence, and thereby becomes a grateful food to man. Also what an evident mark of design is the stone protecting the kernel! The intervention of the stone prevents the second use from interfering with the first."—*Note of the Author.*

find them covered by strong, close tunicles, and attached to the stem according to an order appropriated to each plant, as is seen in the several kinds of grains and of grasses.

In which enumeration, what we have first to notice is, unity of purpose under variety of expedients. Nothing can be more *single* than the design, more *diversified* than the means. Pellicles, shells, pulps, pods, husks, skins, scales armed with thorns, are all employed in prosecuting the same intention. Secondly: we may observe that, in all these cases, the purpose is fulfilled within a just and *limited* degree. We can perceive that, if the seeds of plants were more strongly guarded than they are, their greater security would interfere with other uses. Many species of animals would suffer, and many perish, if they could not obtain access to them. The plant would overrun the soil, or the seed be wasted for want of room to sow itself. It is sometimes as necessary to destroy particular species of plants, as it is at other times to encourage their growth. Here, as in many cases, a balance is to be maintained between opposite uses. The provisions for the preservation of seeds appear to be directed chiefly against the inconstancy of the elements, or the sweeping destruction of inclement seasons. The depredation of animals and the injuries of accidental violence are allowed for in the abundance of the increase. The result is, that out of the many thousand different plants which cover the earth, not a single species, perhaps, has been lost since the creation.

When nature has perfected her seeds, her next care is to disperse them. The seed cannot answer its purpose while it remains confined in its capsule. After the seeds, therefore, are ripened, the pericarpium opens to let them out; and the opening is not like an accidental bursting, but, for the most part, is according to a certain rule in each plant. What I have always thought very extraordinary, nuts and shells, which we can hardly crack with our teeth, divide and make way for the little tender sprout which proceeds

from the kernel. Handling the nut, I could hardly conceive how the plantule was ever to get out of it. There are cases, it is said, in which the seed-vessel, by an elastic jerk at the moment of its explosion, casts the seeds to a distance. We all, however, know that many seeds (those of composite flowers, as of the thistle, dandelion, &c.) are endowed with what are not improperly called *wings;* that is, downy appendages, by which they are enabled to float in the air, and are carried oftentimes by the wind to great distances from the plant which produces them. It is the swelling also of this downy tuft within the seed-vessel that seems to overcome the resistance of its coats, and so to open a passage for the seed to escape.

But the *constitution* of seeds is still more admirable than either their preservation or their dispersion. In the body of the seed of every species of plant, or nearly of every one, provision is made for two grand purposes: first, for the safety of the *germe;* secondly, for the temporary support of the future plant. The sprout, as folded up in the seed, is delicate and brittle beyond any other substance. It cannot be touched without being broken. Yet in beans, pease, grass-seeds, grain, fruits, it is so fenced on all sides, so shut up and protected, that, while the seed itself is rudely handled, tossed into sacks, shovelled into heaps, the sacred particle, the miniature plant, remains unhurt. It is wonderful how long many kinds of seeds, by the help of their integuments, and perhaps of their oils, stand out against decay. A grain of mustard-seed has been known to lie in the earth for a hundred years; and, as soon as it has acquired a favourable situation, to shoot as vigorously as if just gathered from the plant. Then, as to the second point, the temporary support of the future plant, the matter stands thus. In grain, and pulse, and kernels, and pippins, the germe composes a very small part of the seed. The rest consists of a nutritious substance, from which the sprout draws its aliment for some considerable time after it is put forth, viz., until the fibres shot out from the other end of the seed are

able to imbibe juices from the earth in a sufficient quantity for its demand. It is owing to this constitution that we see seeds sprout, and the sprouts make a considerable progress, without any earth at all. It is an economy, also, in which we remark a close analogy between the seeds of plants and the eggs of animals. The same point is provided for in the same manner in both. In the egg, the residence of the living principle, the cicatrix, forms a very minute part of the contents. The white, and the white only, is expended in the formation of the chicken. The yolk, very little altered or diminished, is wrapped up in the abdomen of the young bird when it quits the shell, and serves for its nourishment till it has learned to pick its own food. This perfectly resembles the first nutrition of a plant. In the plant as well as in the animal, the structure has every character of contrivance belonging to it; in both it breaks the transition from prepared to unprepared aliment; in both it is prospective and compensatory. In animals which suck, this intermediate nourishment is supplied by a different source.

In all subjects, the most common observations are the best, when it is their truth and strength which have made them common. There are, of this sort, *two* concerning plants, which it falls within our plan to notice. The *first* relates to what has already been touched upon, their germination. When a grain of corn is cast into the ground, this is the change which takes place. From one end of the grain issues a green sprout; from the other a number of white fibrous threads. How can this be explained? Why not sprouts from both ends? why not fibrous threads from both ends? To what is the difference to be referred but to design; to the different uses which the parts are therefore to serve; uses which discover themselves in the sequel of the process? The sprout or plumule struggles into the air, and becomes the plant, of which, from the first, it contained the rudiments: the fibres shoot into the earth, and thereby both fix the plant to the ground, and collect nourish-

ment from the soil for its support. Now, what is not a little remarkable, the parts issuing from the seed take their respective directions, into whatever position the seed itself happens to be cast. If the seed be thrown into the wrongest possible position; that is, if the ends point in the ground the reverse of what they ought to do, everything, nevertheless, goes on right. The sprout, after being pushed down a little way, makes a bend and turns upward; the fibres, on the contrary, after shooting at first upward, turn down. Of this extraordinary vegetable fact, an account has lately been attempted to be given. "The plumule (it is said) is stimulated by the *air* into action, and elongates itself when *it* is thus most excited. Whence one of these grows upward in quest of its adapted object, and the other downward."* Were this account better verified by experiment than it is, it only shifts the contrivance. It does not disprove the contrivance; it only removes it a little farther back. Who, to use our author's own language, "*adapted* the objects?" Who gave such a quality to these connate parts, as to be susceptible of *different* "stimulation;" as to be "excited" each only by its own element, and precisely by that which the success of the vegetation requires? I say, "which the success of the vegetation requires;" for the toil of the husbandman would have been in vain, his laborious and expensive preparation of the ground in vain, if the event must, after all, depend upon the position in which the scattered seed was sown. Not one seed out of a hundred would fall in a right direction.

Our *second* observation is upon a general property of climbing plants, which is strictly mechanical. In these plants, from each knot or joint, or, as botanists call it, axilla, of the plant, issue, close to each other, two shoots, one bearing the flower and fruit, the other drawn out into a wire, a long, tapering, spiral tendril, that twists itself round anything which lies within its reach. Considering that in this class two purposes

* Darwin's Phytologia, p. 144.

are to be provided for (and together), fructification and support, the fruitage of the plant and the sustentation of the stalk, what means could be used more effectual, or, as I have said, more mechanical, than what this structure presents to our eyes? Why, or how, without a view to this double purpose, do two shoots, of such different and appropriate forms, spring from the same joint, from contiguous points of the same stalk? It never happens thus in robust plants or in trees. "We see not," says Ray, "so much as one tree, or shrub, or herb, that hath a firm and strong stem, and that is able to mount up and stand alone without assistance, *furnished with these tendrils*." Make only so simple a comparison as that between a pea and a bean. Why does the pea put forth tendrils, the bean not? but because the stalk of the pea cannot support itself, the stalk of the bean can. We may add also, as a circumstance not to be overlooked, that, in the pea tribe, these clasps do not make their appearance till they are wanted; till the plant has grown to a height to stand in need of support.

This word "support" suggests to us a reflection upon a property of grasses, of corn, and canes. The hollow stems of these classes of plants are set at certain intervals with joints. These joints are not found in the trunks of trees or in the solid stalks of plants. There may be other uses of these joints; but the fact is, and it appears to be at least one purpose designed by them, that they *corroborate* the stem, which, by its length and hollowness, would otherwise be too liable to break or bend.

Grasses are Nature's care. With these she clothes the earth; with these she sustains its inhabitants. Cattle feed upon their leaves; birds upon their smaller seeds; men upon the larger; for few readers need be told that the plants which produce our bread-corn belong to this class. In those tribes which are more generally considered as grasses, their extraordinary means and powers of preservation and increase, their hardiness, their almost unconquerable disposition to spread, their faculties of reviviscence, coincide with

the intention of Nature concerning them. They thrive under a treatment by which other plants are destroyed. The more their leaves are consumed, the more their roots increase. The more they are trampled upon, the thicker they grow. Many of the seemingly dry and dead leaves of grasses revive, and renew their verdure in the spring.[38] In lofty mountains, where the summer heats are not sufficient to ripen the seeds, grasses abound which are viviparous, and, consequently, able to propagate themselves without seed. It is an observation likewise which has often been made, that herbivorous animals attach themselves to the leaves of grasses, and if at liberty in their pastures to range and choose, leave untouched the straws which support the flowers.*

The GENERAL properties of vegetable nature, or properties common to large portions of that kingdom, are almost all which the compass of our argument allows us to bring forward. It is impossible to follow plants into their several species. We may be allowed, however, to single out three or four of these species as worthy of a particular notice, either by some singular mechanism, or by some peculiar provision, or by both.

I. In Dr. Darwin's Botanic Garden (l. 395, note) is the following account of the *vallisneria*, as it has been observed in the river Rhone: "They have roots at the bottom of the Rhone. The flowers of the *female plant* float on the surface of the water, and are furnished with an *elastic spiral stock*, which extends or contracts as the water rises or falls; this rise or fall, from the torrents which flow into the river, often amounting to many feet in a few hours. The flowers of the *male plant* are produced under water; and, as soon as the fecundating farina is mature, they separate themselves from the plant, rise to

[38] Here, to be correct, we should read, "Many grasses whose leaves are so dry and withered that the plants appear dead, revive and renew their existence in the spring by pushing forth new leaves from the bosom of the former ones."

* Withering, Bot. Arr., vol. i., p. 28, ed. 2d.

the surface, and are wafted by the air, or borne by the currents, to the female flowers." Our attention in this narrative will be directed to two particulars: first, to the mechanism, the "elastic spiral stalk," which lengthens or contracts itself according as the water rises or falls; secondly, to the provision which is made for bringing the male flower, which is produced *under* water, to the female flower, which floats upon the surface.

II. My second example I take from Withering's Arrangement, vol. ii., 209, ed. 3. "The *Cuscuta Europæa* is a parasitical plant. The seed opens, and puts

forth a *little spiral body*, which does *not* seek the earth to take root, but *climbs* in a spiral direction, from right to left, up other plants, from which, by means of vessels, it draws its nourishment." The "little spiral body" proceeding from the seed is to be compared with the fibres which seeds send out in ordinary cases; and the comparison ought to regard both the form of the threads and the direction. They are straight; this is spiral. They shoot downward; this points upward. In the rule and in the exception we equally perceive design.[39]

[39] This statement is incorrect. When the seed of the cuscuta

III. A better known parasitical plant is the evergreen shrub called the *misletoe*. What we have to remark in it is a singular instance of *compensation*. No art hath yet made these plants take root in the earth. Here, therefore, might seem to be a mortal defect in their constitution. Let us examine how this defect is made up to them. The seeds are endued with an adhesive quality so tenacious, that, if they be rubbed upon the smooth bark of almost any tree, they will stick to it. And then what follows? Roots, springing from these seeds, insinuate their fibres into the woody substance of the tree; and the event is, that a misletoe plant is produced next winter.* Of no other plant do the roots refuse to shoot in the ground; of no other plant do the seeds possess this adhesive, generative quality, when applied to the bark of trees.[40]

IV. Another instance of the *compensatory* system is in the autumnal crocus, or meadow saffron (*Colchi-*

opens, it puts forth a little thread-shaped body, namely, a young root, which, as in other plants, plunges into the earth, and from the opposite end elevates a young and slender stem. The latter, after a little while, applies itself to some neighbouring plant, and emits very short broad suckers on the side of its stem, which is placed in contact with the other plant; by these suckers it fastens itself upon the new branch, round which it twines, and, as soon as it is secure in its new station, its root perishes, and it ceases to have any communication with the earth. This property in the cuscuta seems to be given it in consequence of its root not having the power that such parts usually possess of branching, lengthening, and attracting nutriment from the earth. If the cuscuta seed germinates at a distance from any living branch to which it can adhere, it elevates its stem for a short time in the air, and then dies. If it is so placed as to be able to come in contact only with dead branches, still it dies; and it is only when it succeeds in fixing itself upon a living branch that it emits its suckers and continues to exist. Once attached to the living stem of another plant, it takes that for its base, and, turning round once or twice, then darts forth in a straight line, touches something else, which it also fixes in its folds, and thus travels from plant to plant, sometimes covering a very considerable extent of bushes.

* Withering, Bot. Arr., vol. i., p. 203, ed. 3d.

40 These statements are true, not only of the misletoe or *viscum album*, but of the whole natural order *Loranthaceæ*, with one exception.

cum Autumnale). I have pitied this poor plant a thousand times. Its blossom rises out of the ground in the most forlorn condition possible; without a sheet, a fence, a calyx, or even a leaf to protect it: and that, not in the spring, to be visited by summer suns, but under all the disadvantages of the declining year. When we come, however, to look more closely into

the structure of this plant, we find that, instead of its being neglected, Nature has gone out of her course to provide for its security, and to make up to it for all its defects. The seed-vessel, which in other plants is situated within the cup of the flower, or just beneath it, in this plant lies buried ten or twelve inches under ground, within the bulbous root. The tube of the flower, which is seldom more than a few tenths of an inch long, in this plant extends down to the root. The styles in all cases reach the seed-vessel; but it is in this by an elongation unknown to any other plant. All these singularities contribute to one end. "As this plant blossoms late in the year, and probably would not have time to ripen its seeds before the access of winter, which would destroy

them, Providence has contrived its structure such, that this important office may be performed at a depth in the earth out of reach of the usual effects of frost."* That is to say, in the autumn nothing is done above the ground but the business of impregnation: which is an affair between the antheræ and the stigmata, and is probably soon over. The maturation of the impregnated seed, which in other plants proceeds within a capsule, exposed together with the rest of the flower to the open air, is here carried on, and during the whole winter, within the heart, as we may say, of the earth, that is, "out of the reach of the usual effects of frost." But then a new difficulty presents itself. Seeds, though perfected, are known not to vegetate at this depth in the earth. Our seeds, therefore, though so safely lodged, would, after all, be lost to the purpose for which all seeds are intended. Lest this should be the case, "a second admirable provision is made to raise them above the surface when they are perfected, and to sow them at a proper distance," viz., the germe grows up *in the spring*, upon a fruit stalk, accompanied with leaves. The seeds now, in common with those of other plants, have the benefit of the summer, and are sown upon the surface. The order of vegetation externally is this: the plant produces its flowers in September; its leaves and fruits in the spring following.

V. I give the account of the *Dionœa Muscipula*, an extraordinary American plant, as some authors have related it: but whether we be yet enough acquainted with the plant to bring every part of this account to the test of repeated and familiar observation, I am unable to say. "Its leaves are jointed, and furnished with two rows of strong prickles; their surfaces covered with a number of minute glands, which secrete a sweet liquor, that allures the approach of flies. When these parts are touched by the legs of flies, the two lobes of the leaf instantly spring up, the rows of prickles lock themselves fast together, and

* Withering, ubi supra, p. 360.

squeeze the unwary animal to death."* Here, under a new model, we recognise the ancient plan of nature, viz., the relation of parts and provisions to one another, to a common office, and to the utility of the organized body to which they belong. The attracting sirup,[41] the rows of strong prickles, their position so as to interlock the joints of the leaves, and, what is more than the rest, that singular irritability of their surfaces by which they close at a touch, all bear a contributory part in producing an effect, connected either with the defence or with the nutrition of the plant.[42]

* Smellie's Phil. of Nat. Hist., vol i., p. 5.

[41] From this account must be omitted what is said of the sirup that allures the approach of flies. There is no such attraction upon the leaves of the dionœa.

[42] The pitcher-plant, *Nepenthes Distillatoria*, of the East, is another

CHAPTER XXI.

THE ELEMENTS.

When we come to the elements, we take leave of our mechanics; because we come to those things, of the organization of which, if they be organized, we are confessedly ignorant. This ignorance is implied by their name. To say the truth, our investigations are stopped long before we arrive at this point. But then it is for our comfort to find, that a knowledge of the constitution of the elements is not necessary for us. For instance, as Addison has well observed, "we know *water* sufficiently when we know how to boil, how to freeze, how to evaporate, how to make it fresh, how to make it run or spout out, in what quantity and direction we please, without knowing what water is." The observation of this excellent writer has more propriety in it now than it had at the time it was made; for the constitution and the

example which may be given. It grows natural pitchers or tankards, holding from a pint to a quart of pure water. Even when raised in this country under glass, they have been known to hold half a pint. The plate represents these, with their lids, A A, which move on hinges, opening in moist weather, and shutting quite close in dry, to prevent evaporation. When the pitcher becomes full and requires additional support, the hook A behind the lid seizes on some neighbouring tendril, and holds by it. BB are young pitchers just unfolding. This water, which supplies the pitcher, is secreted by the process of vegetation, and is perfectly pure, though the plant grows in a muddy and unwholesome marsh.

The *Palo de Vaca*, or cow-tree of South America, yields a delicious and nutritive milk on its trunk being pierced; and it grows in the most parched soil, and in a climate where rain is unknown during half the year.

The supply of fine water afforded by the *Tillandsia*, or water-with in Jamaica, and by the bejuco, or *Cissus Latifolia* in the East, on cutting, is a fact of the same class. The latter plant also twines round other trees, and affords, as it were, a reservoir for their use.

constituent parts of water appear in some measure to have been lately discovered; yet it does not, I think, appear, that we can make any better or greater use of water since the discovery than we did before it.

We can never think of the elements without reflecting upon the number of distinct uses which are *consolidated* in the same substance. The *air* supplies the lungs, supports fire, conveys sound, reflects light, diffuses smells, gives rain, wafts ships, bears up birds. Ἐξ ὕδατος τα παντα· *water*, besides maintaining its own inhabitants, is the universal nourisher of plants, and, through them, of terrestrial animals; is the basis of their juices and fluids; dilutes their food; quenches their thirst; floats their burdens. *Fire* warms, dissolves, enlightens: is the great promoter of vegetation and life, if not necessary to the support of both.

We might enlarge, to almost any length we please, upon each of these uses; but it appears to me almost sufficient to state them. The few remarks which I judge it necessary to add are as follow:

I. Air is essentially different from earth. There appears to be no necessity for an atmosphere's investing our globe; yet it does invest it: and we see how many, how various, and how important are the purposes which it answers to every order of animated, not to say of organized, beings, which are placed upon the terrestrial surface. I think that every one of these uses will be understood upon the first mention of them, except it be that of *reflecting* light, which may be explained thus: If I had the power of seeing only by means of rays coming directly from the sun, whenever I turned my back upon the luminary I should find myself in darkness. If I had the power of seeing by reflected light, yet by means only of light reflected from solid masses, these masses would shine indeed, and glisten, but it would be in the dark. The hemisphere, the sky, the world, could only be *illuminated*, as it is illuminated, by the light of the sun being from all sides and in every direction, reflected to the eye by particles as numerous, as thickly scattered, and as widely diffused as are those of the air.

Another general quality of the atmosphere is the power of evaporating fluids. The adjustment of this quality to our use is seen in its action upon the sea. In the sea, water and salt are mixed together most intimately; yet the atmosphere raises the water and leaves the salt. Pure and fresh as drops of rain descend, they are collected from brine. If evaporation be solution (which seems to be probable), then the air dissolves the water and not the salt. Upon whatever it be founded, the distinction is critical: so much so, that, when we attempt to imitate the process by art, we must regulate our distillation with great care and nicety, or, together with the water, we get the bitterness, or, at least, the distastefulness of the marine substance; and, after all, it is owing to this original elective power in the air that we can effect the separation which we wish by any art or means whatever.

By evaporation, water is carried up into the air; by the converse of evaporation, it falls down upon the earth. And how does it fall? Not by the clouds being all at once reconverted into water, and descending like a sheet; not in rushing down in columns from a spout, but in moderate drops, as from a colander. Our watering-pots are made to imitate showers of rain. Yet, *à priori*, I should have thought either of the two former methods more likely to have taken place than the last.

By respiration, flame, putrefaction, air is rendered unfit for the support of animal life. By the constant operation of these corrupting principles, the whole atmosphere, if there were no restoring causes, would come at length to be deprived of its necessary degree of purity. Some of these causes seem to have been discovered, and their efficacy ascertained, by experiment; and, so far as the discovery has proceeded, it opens to us a beautiful and a wonderful economy. *Vegetation* proves to be one of them. A sprig of mint, corked up with a small portion of foul air, placed in the light, renders it again capable of supporting light or flame. Here, therefore, is a con-

stant circulation of benefits maintained between the two great provinces of organized nature. The plant purifies what the animal has poisoned; in return, the contaminated air is more than ordinarily nutritious to the plant.[43] *Agitation with water* turns out to be

[43] The experiments of Priestley, confirmed by those of Ingenhouz and Saussure, led to the conclusion that the air is kept pure by the action of plants, these emitting more oxygen gas by day than carbonic acid gas by night. Some doubt was thrown upon this point by the experiments of Mr. Ellis; but these appear to have been removed by Sir H. Davy's remarks and experiments. It seems probable that the plant, growing in the light, decomposes both the carbonic acid which exists, though in a very small proportion, in the atmosphere, and also any that may exist in the water applied to its leaves; for Sennebier found that, when these are immersed in water impregnated with carbonic acid, oxygen gas was evolved, but not if water was used which had been boiled.

The process of vegetation appears to be the great means of supplying the loss of oxygen in the atmosphere; indeed, none other have been as yet discovered. The composition of the atmosphere, in respect of purity, though at one time supposed to vary in different places, is now ascertained to be everywhere invariably the same. It contains about 20 parts of oxygen gas, by measure, in 100, and the remaining 80 are almost entirely nitrogen gas. The only variation is in the slight portion of carbonic acid gas, which never exceeds 1 in 100, and is seldom more than 1 in 1000, supposing the circulation of the air to be unconfined. But the proportion of oxygen to the whole bulk has been found to be the same at nearly 22,000 feet high, and in the deepest valleys; the same in countries widely remote from each other, and differing in climate as well as soil; the same in the most pestilential marshes, or in hospitals, and in the most open and healthy situations. The agitation of the air by winds speedily mixes all its strata, and prevents the effects of breathing and burning from being perceived. Yet a constant consumption of oxygen is going on, wherever there are either living creatures of the hot-blooded class, or fires of any kind, natural or artificial; and this is so balanced by the process of vegetation, that the uniformity of the air's composition is maintained universally.

The union in which the oxygenous and nitrogenous portions of the atmosphere exist, also merits attention. It is ascertained to be of a peculiar kind; for it is not merely that of mechanical admixture, the union of aggregation, inasmuch as the nitrogen gas, being about a seventh part lighter than the oxygen, would rise to the top, and so make the air of higher elevations more pure, contrary to the fact. Nor is it like most other chymical unions, inasmuch as it is both extremely feeble, and is formed without any diminution in the bulk of the two substances combined together.

another of these restoratives. The foulest air, shaken in a bottle with water for a sufficient length of time, recovers a great degree of its purity.[44] Here then again, allowing for the scale upon which nature works, we see the salutary effects of *storms* and *tempests*. The yesty waves which confound the heaven and the sea are doing the very thing which was done in the bottle. Nothing can be of greater importance to the living creation than the salubrity of their atmosphere. It ought to reconcile us, therefore, to these agitations of the elements, of which we sometimes deplore the consequences, to know that they tend powerfully to restore to the air that purity which so many causes are constantly impairing.

II. In Water, what ought not a little to be admired are those negative qualities which constitute its *purity*. Had it been vinous, or oleaginous, or acid; had the sea been filled, or the rivers flowed, with wine or milk, fish, constituted as they are, must have died; plants, constituted as they are, would have withered; the lives of animals which feed upon plants must have perished. Its very *insipidity*, which is one of those negative qualities, renders it the best of all menstrua. Having no taste of its own, it becomes the sincere vehicle of every other. Had there been a taste in water, be it what it might, it would have infected everything we ate or drank with an importunate repetition of the same flavour.

But the kind of union in which the two gases are held is productive of the most beneficial effects. Their disengagement from each other is so easily accomplished, that there is the greatest facility in supporting flame and respiration; while their mixture is so perfect, that the mischiefs are prevented which would arise from their being exhibited either to the lungs or to heated bodies in their pure state.

[44] That agitation with water will remove certain impurities in the air is undeniable, but not all impurities. Animals, by breathing, consume the oxygen, leaving carbonic acid gas and nitrogen gas. Water absorbs the former easily, and bulk for bulk; but of the latter it will only absorb $1\frac{1}{4}$ per cent. So of the products of putrefaction (besides carbonic acid), carbureted hydrogen, and sulphureted hydrogen gases, water will absorb of the latter bulk for bulk, but not above $1\frac{2}{3}$ per cent. of the former.

Another thing in this element not less to be admired, is the constant *round* which it travels; and by which, without suffering either adulteration or waste, it is continually offering itself to the wants of the habitable globe. From the sea are exhaled those vapours which form the clouds: these clouds descend in showers, which, penetrating into the crevices of the hills, supply springs; which springs flow in little streams into the valleys, and, there uniting, become rivers; which rivers, in return, feed the ocean. So there is an incessant circulation of the same fluid; and not one drop, probably, more or less now than there was at the creation. A particle of water takes its departure from the surface of the sea, in order to perform certain important offices to the earth: and, having executed the service which was assigned to it, returns to the bosom which it left.

Some have thought that we have too much water upon the globe, the sea occupying above three quarters of its whole surface. But the expanse of ocean, immense as it is, may be no more than sufficient to fertilize the earth. Or, independently of this reason, I know not why the sea may not have as good a right to its place as the land. It may proportionably support as many inhabitants; minister to as large an aggregate of enjoyment. The land only affords a habitable surface; the sea is habitable to a great depth.

III. Of Fire we have said that it *dissolves*. The only idea, probably, which this term raised in the reader's mind, was that of fire melting metals, resins, and some other substances, fluxing ores, running glass, and assisting us in many of our operations, chymical or culinary. Now these are only uses of an occasional kind, and give us a very imperfect notion of what fire does for us. The grand importance of this dissolving power, the great office, indeed, of fire in the economy of nature, is keeping things in a state of solution, that is to say, in a state of fluidity. Were it not for the presence of heat, or of a certain degree of it, all fluids would be frozen. The ocean itself would be a quarry of ice; universal nature stiff and dead.

We see, therefore, that the elements bear not only a strict relation to the constitution of organized bodies, but a relation to each other. Water could not perform its office to the earth without air; nor exist, as water, without fire.[45]

IV. Of Light (whether we regard it as of the same substance with fire or as a different substance), it is altogether superfluous to expatiate upon the use. No man disputes it. The observations, therefore, which I shall offer, respect that little which we seem to know of its constitution.

Light travels from the sun at the rate of twelve millions of miles in a minute. Urged by such a velocity, with what *force* must its particles drive against (I will not say the eye, the tenderest of animal substances, but) every substance, animate or inanimate, which stands in its way! It might seem to be a force sufficient to shatter to atoms the hardest bodies.

How, then, is this effect, the consequence of such prodigious velocity, guarded against? By a proportionable *minuteness* of the particles of which light is composed. It is impossible for the human mind to imagine to itself anything so small as a particle of light. But this extreme exility, though difficult to conceive, it is easy to prove. A drop of tallow, expended in

[45] The conducting power of different substances are beautifully adapted to the wants of the animal and vegetable kingdom. Snow is so bad a conductor, that it protects the ground effectually in rigorous climates. It is said that in Siberia there have been known to be as many as 38 degrees (Fahrenheit) of difference between the temperature of the air and that of the ground under the snow; the latter not being cooled much below the freezing point. So, too, the animal which, transported to warmer climates, becomes covered with hair, has in its own cold country a woolly covering, and this conducts heat so slowly as to accumulate that which respiration is continually producing.

The peculiarity which distinguishes water from other fluids in freezing likewise merits attention. It expands, instead of continuing to contract, when cooled to the freezing point; and this has the useful effect of crumbling earth, and even rocks, so as to render them fit for assisting the process of vegetation [and also of causing ice to remain at the surface of lakes and streams, instead of sinking in successive layers to the bottom, until the whole mass should become frozen.—*Am. Ed.*]

the wick of a farthing candle, shall send forth rays sufficient to fill a hemisphere of a mile diameter; and to fill it so full of these rays, that an aperture not larger than the pupil of an eye, wherever it be placed in the hemisphere, shall be sure to receive some of them. What floods of light are continually poured from the sun, we cannot estimate; but the immensity of the sphere which is filled with particles, even if it reached no farther than the orbit of the earth, we can in some sort compute; and we have reason to believe that, throughout this whole region, the particles of light lie, in latitude at least, near to one another. The spissitude of the sun's rays at the earth is such, that the number which falls upon a burning-glass of an inch diameter is sufficient, when concentrated, to set wood on fire.

The tenuity and the velocity of particles of light, as ascertained by separate observations, may be said to be proportioned to each other, both surpassing our utmost stretch of comprehension, but proportioned. And it is this proportion alone which converts a tremendous element into a welcome visiter.

It has been observed to me by a learned friend, as having often struck his mind, that, if light had been made by a common artist, it would have been of one uniform *colour:* whereas, by its present composition, we have that variety of colours which is of such infinite use to us for the distinguishing of objects, which adds so much to the beauty of the earth, and augments the stock of our innocent pleasures.

With which may be joined another reflection, viz., that, considering light as compounded of rays of seven different colours (of which there can be no doubt, because it can be resolved into these rays by simply passing it through a prism), the constituent part must be well mixed and blended together to produce a fluid so clear and colourless as a beam of light is when received from the sun.[46]

[46] The substitution of the undulatory for the atomic* theory of

* (See Appendix IX.)

CHAPTER XXII.

ASTRONOMY.*

My opinion of Astronomy has always been, that it is *not* the best medium through which to prove the agency of an intelligent Creator; but that, this being proved, it shows, beyond all other sciences, the magnificence of his operations. The mind which is once convinced, it raises to sublimer views of the Deity than any other subject affords; but it is not so well adapted as some other subjects are to the purpose of

light would produce no alteration whatever in the author's conclusions; and, so far from diminishing, would rather increase the astonishment which the phenomena of Optics are calculated to excite. The same may be said of the discoveries made partly since Dr. Paley's time, partly immediately before the composition of his work, of the two other kinds of rays which accompany those of light; the *calorific* or heat-making, which partly mix with the *colorific* or colour-making, of the spectrum, and partly fall beyond the least refrangible rays; and the *chymical*, which affect certain metallic salts, without either producing illumination or exciting heat, and which are to be found among and beyond the most refrangible rays: so that a beam of white light consists of three kinds of ray, and one of these kinds consists of seven subdivisions, at least according to the Newtonian theory, which divides the colours into seven instead of innumerable gradations of shades. [Some later observers maintain that there are only three primary colours, red, yellow, and blue; and that the seven tints or subdivisions usually noticed in the prismatic spectrum are produced by the superposition of these.—*Am. Ed.*]

* For the articles of this chapter marked with an asterisk, I am indebted to some obliging communications received (through the hands of the Lord Bishop of Elphin) from the Rev. J. Brinkley, M.A., Andrew's Professor of Astronomy in the University of Dublin.—(*Note of the Author.*)—[Professor Brinkley was afterward, as is well known, Bishop of Cloyne. His lordship, upon being made acquainted with the plan of the present publication, kindly communicated the notes now added, and which are marked with his name.]

argument. We are destitute of the means of examining the constitution of the heavenly bodies. The very simplicity of their appearance is against them. We see nothing but bright points, luminous circles, or the phases of spheres reflecting the light which falls upon them. Now we deduce design from relation, aptitude, and correspondence of *parts*. Some degree, therefore, of *complexity* is necessary to render a subject fit for this species of argument. But the heavenly bodies do not, except, perhaps, in the instance of Saturn's ring, present themselves to our observation as compounded of parts at all. This, which may be a perfection in them, is a disadvantage to us, as inquirers after their nature. They do not come within our mechanics.

And what we say of their forms is true of their *motions*. Their motions are carried on without any sensible intermediate apparatus; whereby we are cut off from one principal ground of argumentation, analogy. We have nothing wherewith to compare them; no invention, no discovery, no operation or resource of art which, in this respect, resembles them. Even those things which are made to imitate and represent them, such as orreries, planetaria, celestial globes, &c., bear no affinity to them in the cause and principle by which their motions are actuated. I can assign for this difference a reason of utility; viz., a reason why, though the action of *terrestrial* bodies upon each other be, in almost all cases, through the intervention of solid or fluid substances, yet central attraction does not operate in this manner. It was necessary that the intervals between the planetary orbs should be devoid of any *inert* matter, either fluid or solid, because such an intervening substance would, by its resistance, destroy those very motions which attraction is employed to preserve. This may be a final cause of the difference; but, still, the difference destroys the analogy.

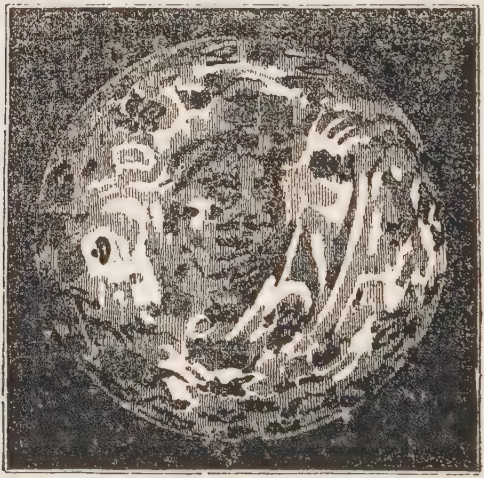
Our ignorance, moreover, of the *sensitive* natures by which other planets are inhabited, necessarily keeps from us the knowledge of numberless utilities,

relations, and subserviences which we perceive upon our own globe.

After all, the real subject of admiration is, that we understand so much of astronomy as we do. That an animal confined to the surface of one of the planets; bearing a less proportion to it than the smallest microscopic insect does to the plant it lives upon; that this little, busy, inquisitive creature, by the use of senses which were given to it for its domestic necessities, and by means of the assistance of those senses, which it has had the art to procure, should have been enabled to observe the whole system of worlds to which its own belongs; the changes of place of the immense globes which compose it; and with such accuracy as to mark out beforehand the situation in the heavens in which they will be found at any future point of time; and that these bodies, after sailing through regions of void and trackless space, should arrive at the place where they were expected, not within a minute, but within a few seconds of a minute, of the time prefixed and predicted: all this is wonderful, whether we refer our admiration to the constancy of the heavenly motions themselves, or to the perspicacity and precision with which they have been noticed by mankind. Nor is this the whole, nor, indeed, the chief part, of what astronomy teaches. By bringing reason to bear upon observation (the acutest reasoning upon the exactest observation), the astronomer has been able, out of the "mystic dance," and the confusion (for such it is) under which the motions of the heavenly bodies present themselves to the eye of a mere gazer upon the skies, to elicit their order and their real paths.

Our knowlege, therefore, of astronomy is admirable, though imperfect; and, amid the confessed desiderata and desideranda which impede our investigation of the wisdom of the Deity in these the grandest of his works, there are to be found in the phenomena ascertained circumstances and laws sufficient to indicate an intellectual agency in three of its principal operations, viz., in choosing, in determining, in

regulating; in *choosing*, out of a boundless variety of suppositions which were equally possible, that which is beneficial; in *determining* what, left to itself, had a thousand chances against convenience, for one in its favour; in *regulating* subjects, as to quantity and degree, which, by their nature, were unlimited with respect to either. It will be our business to offer, under each of these heads, a few instances, such as best admit of a popular explication.[47]



I. Among proofs of choice, one is, fixing the source

47 The above cut represents a telescopic view of the sun, showing some of the remarkable spots which have occasionally appeared on its surface, the largest sometimes exceeding the size of the whole earth. Astronomers, by closely observing the motion which these spots have across the Sun's disc, and the perspective changes which they undergo in assuming a foreshortened or oval form as they approach his edge, previous to their disappearance, have greatly assisted the reasoning, which proves his form to be spherical, and that he has a rotation on his axis.

of light and heat in the *centre* of the system. The sun is ignited and luminous; the planets which move round him are cold and dark. There seems to be no antecedent necessity for this order. The sun might have been an opaque mass; some one, or two, or more, or any, or all the planets, globes of fire. There is nothing in the nature of the heavenly bodies which requires that those which are stationary should be on fire, that those which move should be cold; for, in fact, comets are bodies on fire, or, at least, capable of the most intense heat, yet revolve round a centre: nor does this order obtain between the primary planets and their secondaries, which are all opaque. When we consider, therefore, that the sun is one, that the planets going round it are at least seven;* that it is indifferent to their nature which are luminous and which are opaque: and also in what order, with respect to each other, these two kinds of bodies are disposed, we may judge of the improbability of the present arrangement taking place by chance.

If, by way of accounting for the state in which we find the solar system, it be alleged (and this is one among the guesses of those who reject an intelligent Creator) that the planets themselves are only cooled or cooling masses, and were once, like the sun, many thousand times hotter than red-hot iron, then it follows that the sun also himself must be in his progress towards growing cold, which puts an end to the possibility of his having existed as he is from eternity. This consequence arises out of the hypothesis with still more certainty, if we make a part of it, what the philosophers who maintain it have usually taught, that the planets were originally masses of matter, struck off in a state of fusion from the body of the sun by the percussion of a comet, or by a shock from some other cause with which we are not acquainted; for if these masses, partaking of the na-

* The author says "*at least* seven," because but two of the four new planets since discovered (viz., Ceres, Vesta, Pallas, and Juno) had been observed when he wrote, and their existence might have still been doubted.—*Am. Ed.*

ture and substance of the sun's body, have in process of time lost their heat, that body itself, in time likewise, no matter in how much longer time, must lose its heat also, and therefore be incapable of an eternal duration in the state in which we see it, either for the time to come, or the time past.

The preference of the present to any other mode of distributing luminous and opaque bodies I take to be evident. It requires more astronomy than I am able to lay before the reader to show, in its particulars, what would be the effect to the system of a dark body at the centre and one of the planets being luminous: but I think it manifest, without either plates or calculation, first, that, supposing the necessary proportion of magnitude between the central and the revolving bodies to be preserved, the ignited planet would not be sufficient to illuminate and warm the rest of the system; secondly, that its light and heat would be imparted to the other planets much more irregularly than light and heat are now received from the sun.[48]

(*) II. Another thing in which a choice appears to be exercised, and in which, among the possibilities out of which the choice was to be made, the number

[48] The cut on the opposite page represents the four great planets, as seen through telescopes of considerable powers. Each planet is marked by the symbol which astronomers have for ages been accustomed to use. ♄ is Saturn with his two rings: which are huge bodies, the larger having a diameter more than twenty-five times that of our earth, or above 200,000 miles, and moving with prodigious swiftness round the planet. The seven satellites, or moons, are not represented. ♃ is Jupiter with his spots or belts; his four moons are not represented. Both Saturn and Jupiter are, like our earth, flattened at the poles instead of being perfect spheres, owing to their rotatory motion on their axes. ♂ is Mars, with his singularly formed spots, and reddish light at his poles. ♀ is two figures of Venus, as she is seen in different positions; one a half moon, and in the other like a crescent These *appearances* are called *phases*, from the Greek, and she is the brightest of all the planets. The bulk of Jupiter is 1281 times greater than that of the Earth, of Saturn 995 times; while that of Venus is nine tenths, and that of Mars one half the Earth's bulk. The bulk of the Sun itself is 1,367,000 times that of the Earth.

of those which were wrong bore an infinite proportion to the number of those which were right, is in what geometricians call the *axis of rotation*. This matter I will endeavour to explain. The earth, it is well known, is not an exact globe, but an oblate spheroid, something like an orange. Now the axes of rotation, or the diameters upon which such a body may be

made to turn round, are as many as can be drawn through its centre to opposite points upon its whole surface; but of these axes none are *permanent*, except either its shortest diameter, *i. e.*, that which passes through the heart of the orange from the place where the stalk is inserted into it, and which is but one; or its longest diameters, at right angles with the former,

which must all terminate in the single circumference which goes round the thickest part of the orange. The shortest diameter is that upon which in fact the earth turns, and it is, as the reader sees, what it ought to be, a permanent axis; whereas, had blind chance, had a casual impulse, had a stroke or push at random, set the earth a spinning, the odds were infinite but that they had sent it round upon a wrong axis. And what would have been the consequence? The difference between a permanent axis and another axis is this: When a spheroid in a state of rotatory motion gets upon a permanent axis, it keeps there; it remains steady and faithful to its position: its poles preserve their direction with respect to the plane and to the centre of its orbit: but, while it turns upon an axis which is *not* permanent (and the number of those we have seen infinitely exceeds the number of the other), it is always liable to shift and vacillate from one axis to another, with a corresponding change in the inclination of its poles. Therefore, if a planet once set off revolving upon any other than its shortest or one of its longest axes, the poles on its surface would keep perpetually changing, and it never would attain a permanent axis of rotation. The effect of this unfixedness and instability would be, that the equatorial parts of the earth might become the polar, or the polar the equatorial; to the utter destruction of plants and animals, which are not capable of interchanging their situations, but are respectively adapted to their own. As to ourselves, instead of rejoicing in our temperate zone, and annually preparing for the moderate vicissitude, or, rather, the agreeable succession of seasons which we experience and expect, we might come to be locked up in the ice and darkness of the arctic circle, with bodies neither inured to its rigours, nor provided with shelter or defence against them. Nor would it be much better if the trepidation of our pole, taking an opposite course, should place us under the heats of a vertical sun. But if it would fare so ill with the human inhabitant, who can live under greater varieties of latitude than any other

animal, still more noxious would this translation of climate have proved to life in the rest of creation, and most, perhaps, of all, in plants. The habitable earth and its beautiful variety might have been destroyed by a simple mischance in the axis of rotation.[49]

[49] (Note of Bishop Brinkley.) Either the earth was created a solid, an oblate spheroid, as it now exists, or it must have taken its present form while a soft or fluid mass. In the former case, the argument for design arising from the body revolving on a permanent axis of rotation is of the strongest possible nature. But the present extended knowledge of geology has rendered it highly probable that the earth was originally an ignited mass in a state of fluidity, ignited to the very surface, and by its rotation in that state took its present form as the result of the mutual attraction of its parts and of its rotatory motion. This must be conceded if we do not admit the choice of a permanent axis of rotation. It is, therefore, in the progress through countless ages of the changes on the surface, from the chaotic or primary formation of the geologists to the most interesting state of the surface as it now exists, that we trace the endless arguments for design. However difficult at first sight to be explained, these changes will, when understood, show *one uniform* system, in which all things work together for good.

If we consider the state of the surface before its cooling in a great degree, it must have been wholly unfitted for animal and vegetable life. The admission of this state necessarily lets in the *posterior* and *successive* creation of vegetables and animals. From the vestiges which remain we may conclude, with the highest degree of probability, that for a very long period the surface was only adapted for vegetables and the lowest description of animal life; afterward for animals of an amphibious nature, and such as could exist only on the marshy shores of lakes, or in places occasionally covered with water. By degrees, this state of the surface gave way to others more fitted to a farther supply of animals *to be created*. The principal origin of these changes appears to have been provided in the powers attached to the substances, of whatever nature they may be, existing in the interior of the earth; but these powers have been merely mechanical, and could not originate organized vegetables and animals. The class of changes at the surface, constituting the tertiary formations of the geologist, appear to have been that which was followed by the introduction of a great variety of large animals, many of which are now extinct. The surface was still to be farther improved by making it fitted for a wide extension of animals and of their food. This has been done by the means afforded for the extension and spreading of alluvial matter, so admirably adapted for the growth of plants,

(*) III. All this, however, proceeds upon a supposition of the earth having been formed at first an oblate spheroid. There is another supposition: and perhaps our limited information will not enable us to decide between them. The second supposition is, that the earth, being a mixed mass somewhat fluid, took, as it might do, its present form by the joint action of the mutual gravitation of its parts and its rotatory motion. This, as we have said, is a point in the history of the earth which our observations are not sufficient to determine. For a very small depth below the surface (but extremely small—less, perhaps, than an eight thousandth part, compared with the depth of the centre), we find vestiges of ancient fluidity. But this fluidity must have gone down many hundred times farther than we can penetrate, to enable the earth to take its present oblate form; and whether any traces of this kind exist to that depth, we are ignorant. Calculations were made a few years ago of the mean density of the earth, by comparing the force of its attraction with the force of attraction of a rock of granite, the bulk of which could be ascertained: and the upshot of the calculation was, that the earth, upon an average through its whole sphere, has twice the density of granite, or above five times that of water. Therefore it cannot be a hollow

and, therefore, for the existence of animal life. The changes of surface which have been alluded to are all parts of the same design. Between the successive changes great intervals appear to have elapsed. The imagination is able to form no conception of the length of time since the chaotic state began to change. Notwithstanding the time that must have existed between each change, one uniform plan can be discerned. The animals which we must admit to have been *successively* created, show, by their organization, the same Creator. Thus, if we admit the fluid and chaotic state of the earth (the alternative if we do not admit an original spheroidal formation), there cannot be a question as to the powerful arguments to be derived from the change on the surface and its series of organized beings. Indeed, if the matter be well considered, it will appear to many that the most conclusive arguments for design and *continued* superintendence may be deduced from the researches of the modern geologists.—See second note to chap. xxv., *infra*.

shell, as some have formerly supposed, nor can its internal parts be occupied by central fire or by water. The solid parts must greatly exceed the fluid parts:[50] and the probability is, that it is a solid mass throughout, composed of substances more ponderous the deeper we go. Nevertheless, we may conceive the present face of the earth to have originated from the revolution of a sphere covered by a surface of a compound mixture; the fluid and solid parts separating as the surface becomes quiescent. Here, then, comes in the *moderating* hand of the Creator. If the water had exceeded its present proportion, even but by a trifling quantity compared with the whole globe, all the land would have been covered: had there been much less than there is, there would not have been enough to fertilize the continent. Had the exsiccation been progressive, such as we may suppose to have been produced by an evaporating heat, how came it to stop at the point at which we see it? Why did it not stop sooner? why at all? The mandate of the Deity will account for this; nothing else will.

IV. Of centripetal forces.—By virtue of the simplest law that can be imagined, viz., that a body *continues* in the state in which it is, whether of motion or rest; and, if in motion, goes on in the line in which it was proceeding, and with the same velocity, *unless* there be some cause for change: by virtue, I say, of this law, it comes to pass (what may appear to be a strange consequence) that cases arise[51] in

[50] The author probably refers here to a theory which supposes water to have been the cause of this original fluidity at the earth's surface. If we suppose, however, with Bishop Brinkley in the last note, that this fluidity was occasioned by heat, the author's reasoning, founded on the mean density of the earth, will not apply, since metals in a state of fusion are heavier than granite. We are left, therefore, to infer the original state of the surface of the earth, as well as the relative proportion of its solid and fluid parts at present, from other considerations.—*Am. Ed.*

[51] I. e., cases in which, besides the attractive force drawing the body towards a centre, there is a projectile force tending to carry it forward in space. Motion round a centre is the result of the joint action of these two forces, as we see in a sling, where the arm

which attraction, incessantly drawing a body towards a centre, never brings, nor ever will bring, the body to that centre, but keep it in eternal circulation round it. If it were possible to fire off a cannon-ball with a velocity of five miles in a second, and the resistance of the air could be taken away, the cannon-ball would for ever wheel round the earth instead of falling down upon it. This is the principle which sustains the heavenly motions. The Deity, having appointed this law to matter (than which, as we have said before, no law could be more simple), has turned it to a wonderful account in constructing planetary systems.

The actuating cause in these systems is an attraction which varies reciprocally as the square of the distance; that is, at double the distance, has a quarter of the force; at half the distance, four times the strength; and so on. Now concerning this law of variation we have three things to observe; first, that attraction, for anything we know about it, was just as capable of one law of variation as of another; secondly, that, out of an infinite number of possible laws, those which were admissible for the purpose of supporting the heavenly motions lay within certain narrow limits; thirdly, that of the admissible laws, or those which come within the limits prescribed, the law that actually prevails is the most beneficial. So far as these propositions can be made out, we may be said, I think, to prove *choice* and *regulation:* choice, out of boundless variety; and regulation, of that which, by its own nature, was, in respect of the property regulated, indifferent and indefinite.

1. First, then, attraction, for anything we know about it, was originally indifferent to all laws of variation depending upon change of distance, *i. e.*, just as susceptible of one law as of another. It might have been the same at all distances; it might have increased as the distance increased; or it might have

drawing on the sling constitutes the *centripetal* force, and the projectile impulse given at first by the hand, and afterward maintained by the inertia of the stone, is the *centrifugal* force.—*Am. Ed.*

diminished with the increase of the distance, yet in ten thousand different proportions from the present; it might have followed no stated law at all. If attraction be what Cotes, with many other Newtonians, thought it to be, a primordial property of matter, not dependant upon, or traceable to any other material cause, then, by the very nature and definition of a primordial property, it stood indifferent to all laws. If it be the agency of something immaterial; then also, for anything we know of it, it was indifferent to all laws. If the revolution of bodies round a centre depend upon vortices, neither are these limited to one law more than another.[52]

There is, I know, an account given of attraction, which should seem, in its very cause, to assign to it the law which we find it to observe; and which, therefore, makes that law a law, not of choice, but of necessity; and it is the account which ascribes

[52] The notion of gravitation being a quality inherent in matter, and which could not be separated from its other qualities, has long been abandoned. To argue that it is *necessarily* inherent never could be consistent with the most ordinary perception of the meaning affixed to the terms necessary and contingent. All that could really be intended, therefore, is what we have just now stated in the first sentence of this note. But that, too, appears wholly groundless. The only appearance of a reason was derived from the intensity of all streams of matter proceeding from a centre in every direction being weakened in proportion to their diffusion, and their diffusion being proportioned to the squares of the distance (by similar triangles and the property of the circle, and generally of similar figures). But suppose we overlook the purely hypothetical nature of the connexion between such emanations and gravitation (sanctioned as the theory in a certain degree seems to be by no less an authority than *La Place, Méc. Cél.*, liv. xv., c. l.), and admit the hypothesis that matter, according to its present constitution in other respects, must have gravitation in the inverse duplicate ratio; though an important position may be thus gained or granted in Natural Philosophy, nothing whatever is effected in Natural Theology; for the same power which endowed matter with those qualities from whence this peculiar kind of attractive force results, is only proved to have created that attractive force, and bestowed it upon matter mediately instead of immediately. This, in short, is only another instance of the argument formerly adverted to under the head of "Instinct," Chap. xviii., and which we there stated to be of general application.

attraction to an *emanation* from the attracting body. It is probable that the influence of such an emanation will be proportioned to the spissitude of the rays of which it is composed; which spissitude, supposing the rays to issue in right lines on all sides from a point, will be reciprocally as the square of the distance.[53] The mathematics of this solution we do not call in question: the question with us is, whether there be any sufficient reason for believing that attraction is produced by an emanation. For my part, I am totally at a loss to comprehend how particles streaming *from* a centre should draw a body *towards* it.[54] The impulse, if impulse it be, is all the other way. Nor shall we find less difficulty in conceiving a conflux of particles, incessantly flowing to a centre, and carrying down all bodies along with it, that centre also itself being in a state of rapid motion through absolute space; for, by what source is the stream fed, or what becomes of the accumulation? Add to which, that it seems to imply a contrariety of properties, to suppose an ethereal fluid to *act*, but not to *resist*; powerful enough to carry down bodies with great force towards a centre, yet, inconsistently with the nature of inert matter, powerless and perfectly yielding with respect to the motions which result from the projectile impulse. By calculations drawn from ancient notices of eclipses of the moon, we can

[53] If we suppose rays issuing from a point, in all directions and in right lines, these lines must continually recede from each other as they get farther from this point, and the spissitude or density of the rays at any distance would be inversely as the surface of a sphere, which they may be supposed to fill, and which has for its centre the point of departure. But this surface can be shown by geometry to increase with the square of its distance from the centre: therefore the density of the rays would be *inversely* as the squares of the distance.—*Am. Ed.*

[54] The introduction of the term "particles" here, as well as the author's reasoning, shows that, in his estimation, those who would ascribe attraction to emanations from the attracting body mean *material* emanations. It is due, however, to Buffon, who is believed to have first advanced this theory, to add, that this was not a part of his doctrine, though it was contended by his antagonist Clairault, that the hypothesis necessarily involved it.—*Am. Ed.*

prove that, if such a fluid exist at all, its resistance has had no sensible effect upon the moon's motion for two thousand five hundred years. The truth is, that, except this one circumstance of the variation of the attracting force at different distances agreeing with the variation of the spissitude, there is no reason whatever to support the hypothesis of an emanation; and, as it seems to me, almost insuperable reasons against it.[55]

(*) II. Our second proposition is, that, while the possible laws of variation were infinite, the *admissible* laws, or the laws compatible with the preservation of the system, lie within narrow limits. If the attracting force had varied according to any *direct* law of the distance, let it have been what it would, great destruction and confusion would have taken place. The direct simple proportion of the distance would, it is true, have produced an ellipse: but the perturbing forces would have acted with so much advantage as to be continually changing the dimensions of the ellipse in a manner inconsistent with our terrestrial creation. For instance: if the planet Saturn, so large and so remote, had attracted the earth, both in proportion to the quantity of matter contained in it, which it does; and also in any proportion to its distance, *i. e.*, if it had pulled the harder for being the farther off (instead of the reverse of it), it would have dragged out of its course the globe which we inhabit, and have perplexed its motions to a degree incompatible with our security, our enjoyments, and probably our existence. Of the *inverse* laws, if the centripetal force had changed as the cube of the distance, or in any higher proportion, that is (for I speak to the unlearned), if, at double the distance, the attractive force had been diminished to an eighth part, or to less than that, the consequence would have been, that the planets, if they once began to approach

[55] See note 58 and note 60 to this chapter; where Bishop Brinkley delivers an opinion entitled, undoubtedly, to the greatest respect, but which seems somewhat more decided than the facts as yet warrant, in favour of the ethereal fluids.

the sun, would have fallen into his body; if they once, though by ever so little, increased their distance from the centre, would for ever have receded from it. The laws, therefore, of attraction, by which a system of revolving bodies could be upholden in their motions, lie within narrow limits compared with the possible laws. I much underrate the restriction when I say that, in a scale of a mile, they are confined to an inch. All direct ratios of the distance are excluded, on account of danger from perturbing forces:[56] all

[56] It has been objected to this statement, and the one in p. 97, that such a result would not inevitably happen from planets in any number attracting each other with forces increasing in the direct ratio of their distances, as, indeed, Sir Isaac Newton has shown (Principia, lib. i., prop. 64), how they would revolve in equal times and in elliptical orbits. (See also the 10th and 58th propositions.) In truth, all motion in elliptical orbits is connected with an increase of the force in the direct ratio of the radius vector, if the centre of the figure be the centre of forces, of which Bishop Brinkley must have been, of course, aware.—See p. 97. But if the statement in the text be taken to include the action of other bodies and systems, on the supposition that the attraction is universal—which, it must be remembered, is involved in the very hypothesis of its increasing with the distance—there seems no solid objection to this part, at least, of the observation; for a rushing together of all the systems, the solar and those of the fixed stars, would be the consequence of the attraction increasing according to any power of the distance, while those systems had no motion of projection.*

* Another and most serious evil must have resulted from making attraction increase in the direct ratio of the distance. Bodies at the surface of the earth would, by the greater action of the distant sun and planets, be deprived of that weight, or tendency to fall downward, which now gives them stability. Without weight, our own bodies could neither stand securely, nor exert their power on other bodies; and an apple thrown from the hand, instead of falling to the ground, would have revolved round the earth. Before dismissing this subject, it may be proper to remark that, in comparing the existing laws of gravitation with those which might be conceived, the author seems to have erred in claiming too much as known, while other writers have erred in the opposite direction. As an example of the latter error, we may take a passage from Lord Brougham's Dissertation on the Origin of Evil, appended to the English edition of the present work. He says (see Diss., p. 73, vol. ii.), "Great as have been our achievements in physical astronomy, we are as yet wholly unable to under-

reciprocal ratios, except what lie beneath the cube of the distance, by the demonstrable consequence that every the least change of distance would, under the operation of such laws, have been fatal to the repose and order of the system. We do not know, that is, we seldom reflect, how interested we are in this matter. Small irregularities may be endured: but, changes within these limits, being allowed for, the permanence of our ellipse is a question of life and death to our whole sensitive world.

(*) III. That the subsisting law of attraction falls within the limits which utility requires, when these limits bear so small a proportion to the range of possibilities upon which chance might equally have cast it, is not, with any appearance of reason, to be accounted for by any other cause than a regulation proceeding from a designing mind. But our next proposition carries the matter somewhat farther. We say, in the third place, that, out of the different laws which

stand why a power pervades the system acting inversely as the squares of the distance from the point to which it attracts, rather than a power acting according to any other law; and why it has been the pleasure of the Almighty Architect, that the orbits of the planets should be nearly circular instead of approaching to, or being exactly the same with, many other trajectories of a nearly similar form, though of other properties; nay, instead of being curves of a wholly different class and shape." This is certainly unguarded language. Reasons have already been given, in this and the preceding note, why the force should not increase in the *direct* ratio of the distance. The most rigorous demonstrations have shown farther, that, among *inverse* laws of the distance, all which diminish the central force faster than the *cube* of the distance would be wholly inadmissible, because inconsistent with the permanent revolution of a planet. It is also demonstrable, that the same degree of *simplicity* could not be attained by any other law whatever. Under such circumstances, it is hardly presumptuous to maintain that we do understand some of the reasons for the selection of the existing law, though those reasons may not be, by any means, the strongest ones. It is a subject on which we ought, without doubt, to speak with much diffidence; for to do full justice to all the reasons which led to the adoption of any natural law, would require little less than a perfect acquaintance with the whole constitution of every part of the creation. In this respect the author has not always maintained sufficient reserve See especially the chapter on Divine Benevolence.—*Am. Ed.*

lie within the limits of admissible laws, the *best* is made choice of; that there are advantages in this particular law which cannot be demonstrated to belong to any other law; and concerning some of which it can be demonstrated that they do not belong to any other.

(*) 1. While this law prevails between each particle of matter, the *united* attraction of a sphere composed of that matter observes the same law. This property of the law is necessary to render it applicable to a system composed of spheres, but it is a property which belongs to no other law of attraction that is admissible. The law of variation of the united attraction is in no other case the same as the law of attraction of each particle, one case excepted, and that is of the attraction varying directly as the distance; the inconvenience of which law, in other respects, we have already noticed.

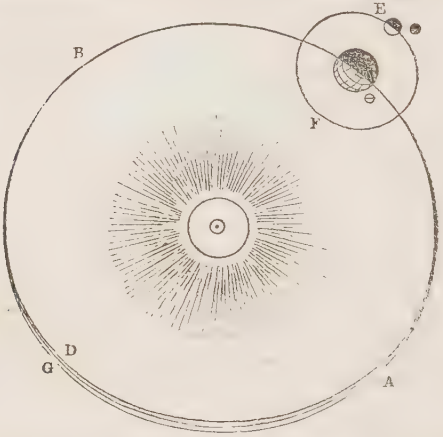
We may follow this regulation somewhat farther, and still more strikingly perceive that it proceeded from a designing mind. A law both admissible and convenient was requisite. In what way is the law of the attracting globes obtained? Astronomical observations and terrestrial experiments show that the attraction of the globes of the system is made up of the attraction of their parts: the attraction of each globe being compounded of the attractions of its parts. Now the admissible and convenient law which exists could not be obtained in a system of bodies gravitating by the united gravitation of their parts, unless each particle of matter were attracted by a force varying by one particular law, *viz.*, varying inversely as the square of the distance: for if the action of the particles be according to any other law whatever, the admissible and convenient law, which is adopted, could not be obtained. Here, then, are clearly shown regulation and design. A law both admissible and convenient was to be obtained; the mode chosen for obtaining that law was by making *each* particle of matter act. After this choice was made, then farther attention was to be given to each particle of

matter, and one, and one only, particular law of action to be assigned to it. No other law would have answered the purpose intended.

(*) 2. All systems must be liable to *perturbations*. And, therefore, to guard against these perturbations, or, rather, to guard against their running to destructive lengths, is perhaps the strongest evidence of care and foresight that can be given. Now we are able to demonstrate of our law of attraction, what can be demonstrated of no other, and what qualifies the dangers which arise from cross but unavoidable influences, that the action of the parts of our system upon one another will not cause permanently increasing irregularities, but merely periodical or vibratory ones; that is, they will come to a limit, and then go back again. This we can demonstrate only of a system, in which the following properties concur, *viz.*, that the force shall be inversely as the square of the distance; the masses of the revolving bodies small, compared with that of the body at the centre; the orbits not much inclined to one another; and their eccentricity little. In such a system, the grand points are secure. The mean distances and periodic times, upon which depend our temperature and the regularity of our year, are constant. The eccentricities, it is true, will still vary; but so slowly, and to so small an extent, as to produce no inconvenience from fluctuation of temperature and season. The same as to the obliquity of the planes of the orbits. For instance, the inclination of the ecliptic to the equator will never change above two degrees (out of ninety), and that will require many thousand years in performing.[57]

[57] The cut on the following page represents the oval A B, nearly circular, in which the Earth ⊖ moves round the Sun ⊙ in one of the foci, while the Moon, E, moves round the Earth in a similar curve, E F. These curves vary (as do the paths of all the planets and their satellites), becoming more and more bulged, till they bulge out by a certain quantity, G D, so as to be A G B, and then the curve they describe flattens constantly, till it becomes A D B, but never more, in consequence of the four circumstances mentioned in the text.

It has been rightly also remarked, that if the great planets, Jupiter and Saturn, had moved in lower



The celebrated proposition of La Place, respecting the eccentricities of the planetary orbits, and their deviation from a nearly circular form—that upon which the stability of the system mainly rests—may be comprehended by this illustration. Suppose three vessels of different burden sail from one port to another, and take such courses, that, multiplying the tunnage of each by the square of the deviation in miles which it makes from the straight line, or shortest distance, between the two ports, and adding the three products together, the sum is at every instant of the voyage the same—say 90—the vessels being of 10, 22½, and 90 tuns burden respectively. It is clear that none of them can ever deviate beyond a certain distance from the straight course, for the greatest possible deviation would be three miles (the square root of the quotient of 90 divided by the tunnage of the smallest vessel), and this supposes neither of the other two to deviate at all; if they also had their deviations, that would make the smallest vessel's deviation so much the less. In like manner, the second vessel never could deviate more than two, nor the largest more than one. But these deviations would always be lessened in proportion as the other vessels deviated. If we suppose the three to start from three ports in a straight line from each other, and one port to be 64, another 81, and the third 100 miles from the port of destina-

spheres, their influences would have had much more effect as to disturbing the planetary motions than

tion, and make the condition to be, that the sums of each vessel's tunnage multiplied by the square of its deviation, and the products by the sums eight, nine, and ten respectively (the square roots of the distances of the three ports of departure), shall be always equal to the same number, *e. g.*, 90, the case will resemble more closely the one we are illustrating; for the proposition of La Place is, that the sum of the products of the square roots of the transverse axes of the orbits, multiplied by the squares of the eccentricities and by the masses, is always the same (*Méc. Cél.*, liv. ii., c. 7 and 8, especially s. 57, 61).

The case which we have taken, however, is only by way of illustration, and does not resemble the one in question as to particulars. Moreover, in order that all the three vessels may be able to obey the rule during each part of their course, we must suppose one of them to start from a point on one side of the port, and the same vessel, or another of them, to make a port different from the port of destination. This difficulty would be removed by supposing the condition to be, that the sums of the products should *never exceed* a certain amount.

In the case put it is clear that, practically speaking, no combination among the navigators could make the vessels perform their voyage according to the condition, unless by two of the vessels going in the straight line, and the third in a line parallel to it. Nothing but a principle acting equally on the screws of all the vessels, like gravitation or like instinct, could keep them to the terms of the rule if they were all to deviate and to vary in their deviations. But that insects should, by some such instinct, be able to perform an operation of this kind, seems quite possible. Each bee acts in the construction of its cells in this way; for it keeps to the rule accurately, and it acts in perfect concert with others; at least it acts so as to produce the effect of concert.

The theorem to which we have here alluded, as well as those two similar theorems which make the mean motion and mean longitudes of the three first satellites of Jupiter, follow a certain fixed rule, the difference between thrice the motions and longitudes of the second, and the motions and longitudes of the first added to twice those of the third, being an invariable quantity (that is, 0 in the case of the motions, and 180 degrees in the case of the longitudes), are all deducible by strict mathematical reasoning, but from data which are not necessarily true; for these theorems depend, among other things, upon the motions of revolution throughout the system being in the same direction. La Place has expressed an opinion, that the relation just mentioned as to Jupiter's satellites was not the same when the motion began, but was established by the mutual actions of these bodies, which he has shown were sufficient to establish the relation at first, as well as

they now have. While they revolve at so great distances from the rest, they act almost equally on the sun and on the inferior planets; which has nearly the same consequence as not acting at all upon either.

If it be said that the planets might have been sent round the sun in exact circles, in which case, no change of distance from the centre taking place, the law of variation of the attracting power would have never come in question, one law would have served as well as another; an answer to the scheme may be drawn from the consideration of these same perturbing forces. The system retaining in other respects its present constitution, though the planets have been at first sent round in exact circular orbits, they could not have kept them; and if the law of attraction had not been what it is, or, at least, if the prevailing law had transgressed the limits above assigned, every evagation would have been fatal; the planet once drawn, as drawn it necessarily must have been, out of its course, would have wandered in endless error.[58]

to maintain it afterward. This may or it may not be; that is, it may or it may not be true that those relations were established in the course of the system's action; but no kind of argument arises from hence against the designing power, even if we admit the supposition of that great mathematician; for then it would only follow that the same principle which was appointed to preserve had also been appointed to create the relation of stability.—(See *Méc. Cél.*, liv. ii., c. 8, s. 66; liv. viii., c. 6, s. 15, and c. 10, s. 29. See also Mrs. Somerville's truly profound and admirable work, *Mechanism of the Heavens*, b. iv., c. 1, s. 849, *et seq.*)

[58] (Note of Bishop Brinkley.) Many suppose attraction an emanation, and the law of attraction (the inverse square of the distance), which exists, to be actually *necessary* and deducible from *equal* quantities of the attractive force being spread over each spherical surface surrounding the attractive centre. If this were so, all attracting matter must act according to the same law. This is not the case in many instances that might be adduced. The attraction by which particles of matter adhere together is obviously not of this nature. Chymical action furnishes many exceptions to this law. It may, indeed, be said, that a polarizing power may be joined to an attractive force acting as above mentioned. We know very imperfectly, or rather nothing, of the nature of this polarization; but we know it is not extended to the

(*) V. What we have seen in the law of the centripetal force, *viz.*, a choice guided by views of utility, and a choice of one law out of thousands which might equally have taken place, we see no less in the *figures* of the planetary orbits. It was not enough to fix the law of the centripetal force, though by the wisest choice; for even under that law it was still competent to the planets to have moved in paths possessing so great a degree of eccentricity, as, in the course of every revolution, to be brought very near to the sun, and carried away to immense distances from him. The comets actually move in orbits of this sort; and, had the planets done so, instead of going round in orbits nearly circular, the change from one extremity of temperature to another must, in ours at least, have destroyed every animal and plant upon its surface. Now the distance from the centre at which a planet sets off, and the absolute force of attraction at that distance being fixed, the figure of its orbit, its being a circle, or nearer to, or farther off from a circle, *viz.*, a rounder or a longer oval, depends upon two things, the velocity with which, and the direction in which, the planet is projected. And these, in order to produce a right result, must be both brought within certain narrow limits. One, and only one velocity, united with one, and only one direction, will produce a perfect circle. And the velocity must be near to this velocity, and the direction also near to this direction, to produce orbits such as the planetary orbits are, nearly circular; that is, ellipses with small eccentricities. The velocity and the direction

actions of the sun and planetary masses on each other. Why was it not extended to these? The simple answer is, that it would not only have been useless, but it would have interfered with the purposes for which these bodies were designed. Thus these great bodies are moved by laws of the utmost simplicity, while their component parts act on each other by a combination of forces of various kinds; which forces appear to act at small distances only, while the forces on which depend the welfare and preservation of our earth and the planets act through a vast extent of space, and by one simple and uniform law, in which there is no conflicting interference of other actions.

must *both* be right. If the velocity be wrong, no direction will cure the error; if the direction be in any considerable degree oblique, no velocity will produce the orbit required. Take, for example, the attraction of gravity at the surface of the earth. The force of that attraction being what it is, out of all the degrees of velocity, swift and slow, with which a ball might be shot off, none would answer the purpose of which we are speaking but what was nearly that of five miles in a second. If it were less than that, the body would not get round at all, but would come to the ground: if it were in any considerable degree more than that, the body would take one of those eccentric courses, those long ellipses, of which we have noticed the inconvenience. If the velocity reached the rate of seven miles in a second, or went beyond that, the ball would fly off from the earth, and never be heard of more. In like manner, with respect to the *direction*; out of the innumerable angles in which the ball might be sent off (I mean angles formed with a line drawn in the centre), none would serve but what was nearly a right one; out of the various directions in which the cannon might be pointed, upward and downward, every one would fail but what was exactly or nearly horizontal. The same thing holds true of the planets: of our own among the rest. We are entitled, therefore, to ask, and to argue the question, Why did the projectile velocity and projectile direction of the earth happen to be nearly those which would retain it in a *circular* form? Why not one of the infinite number of velocities, one of the infinite number of directions, which would have made it approach much nearer to, or recede much farther from, the sun?

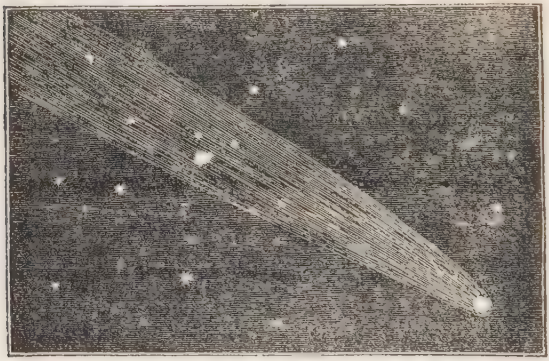
The planets going round, all in the same direction, and all nearly in the same plane, afforded to Buffon a ground for asserting that they had all been shivered from the sun by the same stroke of a comet, and by that stroke projected into their present orbits. Now, besides that this is to attribute to chance the fortunate concurrence of velocity and direction which we

have been here noticing, the hypothesis, I apprehend, is inconsistent with the physical laws by which the heavenly motions are governed. If the planets were struck off from the surface of the sun, they would return to the surface of the sun again. Nor will this difficulty be got rid of by supposing that the same violent blow which shattered the sun's surface, and separated large fragments from it, pushed the sun himself out of his place; for the consequence of this would be, that the sun and system of shattered fragments would have a progressive motion, which, indeed, may possibly be the case with our system; but then each fragment would, in every revolution, return to the surface of the sun again. The hypothesis is also contradicted by the vast difference which subsists between the *diameters* of the planetary orbits. The distance of Saturn from the sun (to say nothing of the Georgium Sidus) is nearly five-and-twenty times that of Mercury; a disparity which it seems impossible to reconcile with Buffon's scheme. Bodies starting from the same place, with whatever difference of direction or velocity they set off, could not have been found at these different distances from the centre, still retaining their nearly circular orbits. They must have been carried to their proper distances before they were projected.*

To conclude: In astronomy, the great thing is to raise the imagination to the subject, and that often-

* "If we suppose the matter of the system to be accumulated in the centre of its gravity, *no* mechanical principles, with the assistance of this power of gravity, could separate the vast mass into such parts as the sun and planets; and, after carrying them to their different distances, projected them in their several directions, preserving still the quantity of action and reaction, or the state of the centre of gravity of the system. Such an exquisite structure of things could only arise from the contrivance and powetful influences of an intelligent, free, and most potent agent. The same powers, therefore, which at present govern the material universe, and conduct its various motions, are *very different* from those which were necessary to have produced it from nothing, or to have disposed it in the admirable form in which it now proceeds."—*Maclaurin's Account of Newton's Philosophy*, p. 407., ed. 3.

times in opposition to the impression made upon the senses. An illusion, for example, must be got over arising from the distance at which we view the heavenly bodies, *viz.*, the apparent *slowness* of their motion.[59] The moon shall take some hours in getting



[59] This cut represents the comet of 1811, the fixed stars being seen through its tail, which extended 123,000,000 of miles. The period of its revolution is calculated at above 3300 years. The great comet of 1680 was calculated by Sir Issac Newton to have a tail of 80,000,000 of miles, immediately after its perihelion, a periodic time of 575 years, and a velocity, when nearest the sun, of 880,000 miles in an hour. Its orbit is so much elongated that its greatest distance from the sun is estimated at near 3000 millions of miles, and its least at only 150,000 miles. Halley's comet, which appeared in 1682, 1759, and 1835—probably also in 1531 and 1607—has a mean distance from the sun of 1,705 millions of miles, the earth's mean distance being 96,000,000; but while the earth's orbit is so nearly circular that the planet's greatest distance is only a thirtieth part more than its smallest, this comet's aphelion (or greatest) distance is above 3355 millions, and its perihelion (or least) distance only 55 millions, or sixty-one times less. So the transverse (or longer) axis of its orbit is four times the length of the conjugate (or shorter) axis; whereas, the two axes of the earth's orbit differ by only a 7000th part from one another. Most of the planetary orbits are nearly circular also, that of Pallas being the most elongated, and in the proportion of only 5 to 3. But the orbits of the comets have every variety of shape as well as size, and their motion the greatest difference in

half a yard from a star which it touched. A motion so deliberate we may think easily guided. But what is the fact? The moon, in fact, is all this while driving through the heavens at the rate of considerably more than two thousand miles in an hour; which is more than double that with which a ball is shot off from the mouth of a cannon. Yet is this prodigious rapidity as much under government as if the planet proceeded ever so slowly, or were conducted in its course inch by inch. It is also difficult to bring the imagination to conceive (what yet, to judge tolerably of the matter, is necessary to conceive) how *loose*, if we may so express it, the heavenly bodies are. Enormous globes, held by nothing, confined by nothing, are turned into free and boundless space, each to seek its course by the virtue of an invisible principle; but a principle, one, common, and the same in all, and ascertainable. To preserve such bodies from being lost, from running together in heaps, from hindering and distracting one another's motions, in a degree inconsistent with any continuing order; *h. e.*, to cause them to form planetary systems; systems that, when formed, can be upheld; and, most especially, systems accommodated to the organized and sensitive natures which the planets sustain, as we know to be the case, where alone we can know what the case is, upon our earth: all this requires an intelligent interposition, because it can be demonstrated concerning it that it requires an adjustment of force, distance, direction, and velocity, out of the reach of chance to have produced; an adjustment, in its view to utility, similar to that which we see in ten thousand subjects of nature which are nearer to us, but in power, and in the extent of space through which that power is exerted, stupendous.[60]

velocity; yet they appear all to follow the same general laws, and these the same by which the planetary motions are governed.

[60] (Note of Bishop Brinkley. See Note 55.—Since the publication of Dr. Paley's "Natural Theology," it has been ascertained that a resisting medium is actually diffused through our system. But it is of so rare a nature, that the planets will not be effected

But many of the heavenly bodies, as the sun and fixed stars, are *stationary*. Their rest must be the ef-

by it for an immense period. The existence of this resisting medium has been ascertained by the successive revolutions of the small comet, the orbit of which was first accurately computed by M. Encke, and its identity verified on several successive returns. We had before a knowledge of the weak action of comets on the planets, and of the consequent smallness of their masses. It was also inferred that they were bodies of small density, and, consequently, would be more sensibly affected in their motions through a resisting medium. This comet was found in 1795 by Miss Herschel, and observed also by her brother. His account of it, when considered with reference to what has since been ascertained as to the resistance it meets with in its course, is remarkable (vide Phil. Trans. 1796, p. 133): "The comet is now centrically on a small star. It is a small telescope star of about the eleventh or twelfth magnitude, and is double, very unequal; with a power of 287 I can see the smallest of the two stars perfectly well. This shows how little density there is in the comet, which is evidently nothing but what may be called a collection of vapours." This comet is also remarkable for the shortness of its period, about three and a half years, not receding so far from the sun as the planet Jupiter. In the solar system the difference between the two classes of bodies which revolve round the sun, and are retained in their orbits by the solar action, is most marked and distinct. Comets so numerous serve for purposes entirely unknown to us. Indeed, hitherto no probable conjecture has been formed as to those purposes. That they are not the habitations of beings similar to those which exist on the earth, is nearly certain. The earth and planets appear wisely adapted, in a variety of ways, for the convenience and preservation of animals and vegetables. The comets are not so adapted. In one case orbits nearly circular were required, in the other they were not required.

There is another circumstance in which design appears strongly marked, although we cannot explain the purport of it. The planets appear to be placed at distances from the sun according to a certain law. This was remarked by Professor Bode, and that the law was not complete unless a planet existed between Mars and Jupiter. The new planets were afterward discovered, each of them circulating between Jupiter and Mars, at a distance from the sun conformable to the conjectured law.* The cause of more than one planet being found at this distance has, with some degree of probability, been derived from the hypothesis, that a large planet has been shattered into fragments, which fragments are the planets Ceres, Vesta, Pallas, and Juno. That wonderful changes occasionally offer themselves to our notice, as wonderful as the

* See first note to Chap. xxv., infra.

fect of an absence or of an equilibrium of attractions It proves also that a projectile impulse was originally given to some of the heavenly bodies and not to others. But farther: if attraction act at all distances, there can only be one quiescent centre of gravity in the universe; and all bodies whatever must be approaching this centre or revolving round it. According to the first of these suppositions, if the duration of the world had been long enough to allow of it, all its parts, all the great bodies of which it is composed, must have been gathered together in a heap round this point. No changes, however, which have been observed, afford us the smallest reason for believing that either the one supposition or the other is true: and then it will follow, that attraction itself is controlled or suspended by a superior agent; that there is a power above the highest of the powers of material nature; a will which restrains and circumscribes the operations of the most extensive.*

destruction of a planet, is exemplified in the appearance and disappearance of a fixed star. A star suddenly appeared in 1571 of a degree of splendour exceeding all the other fixed stars. It was seen during sixteen months, and continually diminished in brightness till it disappeared. All the circumstances of it are well attested by many astronomers and others. It remained fixed in one spot of the heavens, without changing its place among the stars by any perceptible quantity. Although astronomical instruments at that time did not admit of a degree of precision to be compared with those of the present time, yet the observations made on it by several astronomers fully suffice to show that its distance from us must have been at least between 3000 and 4000 times that of the sun from the earth, or 300,000 millions of miles.

* It must here, however, be stated, that many astronomers deny that any of the heavenly bodies are absolutely stationary. Some of the brightest of the fixed stars have certainly small motions; and of the rest the distance is too great, and the intervals of our observation too short, to enable us to pronounce with certainty that they may not have the same. The motions in the fixed stars which have been observed are considered either as proper to each of them, or as compounded of the motion of our system and of motions proper to each star. By a comparison of these motions, a motion in our system is supposed to be discovered. By continuing this analogy to other and to all systems, it is possible to suppose that attraction is unlimited, and that the whole material universe is revolving round some fixed point within its containing sphere or space.—*Note of the Author.*

CHAPTER XXIII.

OF THE PERSONALITY OF THE DEITY.

CONTRIVANCE, if established, appears to me to prove everything which we wish to prove. Among other things, it proves the *personality* of the Deity, as distinguished from what is sometimes called nature, sometimes called a principle: which terms, in the mouths of those who use them philosophically, seem to be intended to admit and to express an efficacy, but to exclude and to deny a personal agent. Now that which can contrive, which can design, must be a person. These capacities constitute personality, for they imply consciousness and thought. They require that which can perceive an end or purpose, as well as the power of providing means, and directing them to their end.* They require a centre, in which perceptions unite, and from which volitions flow; which is mind. The acts of a mind prove the existence of a mind; and, in whatever a mind resides, is a person. The seat of intellect is a person.[61] We have no au-

* Priestley's Letters to a Philosophical Unbeliever, p. 153, ed. 2

[61] The terms "person" and "personality" are ambiguous; the signification varying according to the metaphysical views of those who employ them. In the estimation of some there can be no personality without free-will, self-consciousness, and a moral sense; while, in the opinion of others, neither the first nor the last of these elements would be essential. Usage having restricted the application of the term to men as distinguished from brutes, the ideas we attach to it will depend upon our views in regard to the distinguishing attributes of man's nature. In the theory of Paley, as must be obvious to those who have examined his Elements of Moral Philosophy, the number of these distinguishing attributes is small; and hence it might be expected that his notions of *personality* would be narrower than suits the opinions of those who embrace a different, and, as the present writer believes, a sounder philosophy. Yet this hardly warrants the severe measure of criticism which has been dealt out to him by some able

thority to limit the properties of mind to any particular corporeal form, or to any particular circumscription of space. These properties subsist in created nature under a great variety of sensible forms. Also, every animated being has its *sensorium;* that is, a certain portion of space, within which perception and volition are exerted. This sphere may be enlarged to an indefinite extent; may comprehend the universe; and, being so imagined, may serve to furnish us with as good a notion as we are capable of forming of the *immensity* of the Divine Nature, *i. e.*, of a divine Being, infinite as well in essence as in power, yet, nevertheless, a person.

"No man hath seen God at any time." And this, I believe, makes the great difficulty. Now it is a dif-

writers. Dr. Marsh, of our own country, in one of the valuable notes appended to his edition of Coleridge's Aids to Reflection, has followed the example of that powerful but eccentric genius, in condemning the general course of reasoning adopted by Paley in this volume, and he selects the passage now under consideration as especially obnoxious to censure. To ground an argument for personality on *contrivance* is, in his opinion, to raise brutes to the rank of persons, since *they* contrive; and leaves us without any conclusive proof that God is either free, self-conscious, or even intelligent. (See note, p. 255.) Now in regard to this I would observe, 1st. That Paley's main object in using the term under dispute is to exclude the idea of a First Cause (such as Nature), which has efficacy without personal agency; leaving the nature of this personality to be discussed in the next chapter. 2d. The *contrivance* on which he relies is not such as brutes exhibit; since, to use his own language, it implies "consciousness and thought." Now whatever we may think of some of the contrivances of animals, which, being adapted to novel and varying circumstances, doubtless indicate a degree of "thought" as distinguished from mere instinct, yet no one, it is presumed, would claim, even for such cases, the prerogative of "consciousness." The truth seems to be, that we interpret marks of design in nature by reference to our own consciousness or experience; and, since in our own case we find contrivance is always connected with deliberation, self-consciousness, and choice, we judge that it must be so with God, and look up to Him as alike free and intelligent. It is otherwise when we look at the contrivances of brutes, which we cannot but regard as in a good measure necessitated, and which lead us, therefore, to raise our admiration above the immediate agent to Him in whom it lives and has its being.—*Am. Ed.*

ficulty which chiefly arises from our not duly estimating the state of our faculties. The Deity, it is true, is the object of none of our senses: but reflect what limited capacities animal senses are. Many animals seem to have but one sense, or perhaps two at the most; touch and taste. Ought such an animal to conclude against the existence of odours, sounds, and colours? To another species is given the sense of smelling. This is an advance in the knowledge of the powers and properties of nature: but, if this favoured animal should infer, from its superiority over the class last described, that it perceived everything which was perceptible in nature, it is known to us, though perhaps not suspected by the animal itself, that it proceeded upon a false and presumptuous estimate of its faculties. To another is added the sense of hearing; which lets in a class of sensations entirely unconceived by the animal before spoken of; not only distinct, but remote from any which *it* had ever experienced, and greatly superior to them. Yet this last animal has no more ground for believing that its senses comprehend all things, and all properties of things, which exist, than might have been claimed by the tribes of animals beneath it; for we know that it is still possible to possess another sense, that of sight, which shall disclose to the percipient a new world. This fifth sense makes the animal what the human animal is: but to infer that possibility stops here; that either this fifth sense is the last sense, or that the five comprehend all existence, is just as unwarrantable a conclusion as that which might have been made by any of the different species which possessed fewer, or even by that, if such there be, which possessed only one. The conclusion of the one-sense animal and the conclusion of the five-sense animal stand upon the same authority. There may be more and other senses than those which we have. There may be senses suited to the perception of the powers, properties, and substance of spirits. These may belong to higher orders of rational agents; for there is not the smallest reason for supposing that we

are the highest, or that the scale of creation stops with us.

The great *energies* of nature are known to us only by their effects. The substances which produce them are as much concealed from our senses as the Divine essence itself. *Gravitation*, though constantly present; though constantly exerting its influence; though everywhere around us, near us, and within us; though diffused throughout all space, and penetrating the texture of all bodies with which we are acquainted, depends, if upon a fluid, upon a fluid which, though both powerful and universal in its operation, is no object of sense to us; if upon any other kind of substance or action, upon a substance and action from which *we* receive no distinguishable impressions. Is it then to be wondered at that it should, in some measure, be the same with the Divine nature?

Of this, however, we are certain, that, whatever the Deity be, neither the *universe*, nor any part of it which we see, can be He. The universe itself is merely a collective name: its parts are all which are real, or which are *things*. Now inert matter is out of the question, and organized substances include marks of contrivance. But whatever includes marks of contrivance, whatever, in its constitution, testifies design, necessarily carries us to something beyond itself, to some other being, to a designer prior to, and out of itself. No animal, for instance, can have contrived its own limbs and senses: can have been the author to itself of the design with which they were constructed. That supposition involves all the absurdity of self-creation, *i. e.*, of acting without existing. Nothing can be God which is ordered by a wisdom and a will which itself is void of; which is indebted for any of its properties to contrivance *ab extra*. The *not* having that in his nature which requires the exertion of another prior being (which property is sometimes called self-sufficiency, and sometimes self-comprehension), appertains to the Deity as his essential distinction, and removes his nature from that of all things which we see: which consideration contains

the answer to a question that has sometimes been asked, namely, Why, since something or other must have existed from eternity, may not the present universe be that something? The contrivance perceived in it proves that to be impossible. Nothing contrived can, in a strict and proper sense, be eternal, forasmuch as the contriver must have existed before the contrivance.

Wherever we see marks of contrivance, we are led for its cause to an *intelligent* author. And this transition of the understanding is founded upon uniform experience. We see intelligence constantly contriving; that is, we see intelligence constantly producing effects, marked and distinguished by certain properties; not certain particular properties, but by a kind and class of properties, such as relation to an end, relation of parts to one another and to a common purpose. We see, wherever we are witnesses to the actual formation of things, nothing except intelligence producing effects so marked and distinguished. Furnished with this experience, we view the productions of nature. We observed *them* also marked and distinguished in the same manner. We wish to account for their origin. Our experience suggests a cause perfectly adequate to this account. No experience, no single instance or example, can be offered in favour of any other. In this cause, therefore, we ought to rest: in this cause the common sense of mankind has, in fact, rested, because it agrees with that which, in all cases, is the foundation of knowledge, the undeviating course of their experience. The reasoning is the same as that by which we conclude any ancient appearances to have been the effects of volcanoes or inundations; namely, because they resemble the effects which fire and water produce before our eyes; and because we have never known these effects to result from any other operation. And this resemblance may subsist in so many circumstances, as not to leave us under the smallest doubt in forming our opinion. Men are not deceived by this reasoning: for, whenever it happens, as it

sometimes does happen, that the truth comes to be known by direct information, it turns out to be what was expected. In like manner, and upon the same foundation (which, in truth, is that of experience), we conclude that the works of nature proceed from intelligence and design; because, in the properties of relation to a purpose, subservience to a use, they resemble what intelligence and design are constantly producing, and what nothing except intelligence and design ever produce at all. Of every argument, which would raise a question as to the safety of this reasoning, it may be observed, that if such argument be listened to, it leads to the inference, not only that the present order of nature is insufficient to prove the existence of an intelligent Creator, but that no imaginable order would be sufficient to prove it; that *no* contrivance, were it ever so mechanical, ever so precise, ever so clear, ever so perfectly like those which we ourselves employ, would support this conclusion; a doctrine to which I conceive no sound mind can assent.

The force, however, of the reasoning is sometimes sunk by our taking up with mere names. We have already noticed,* and we must here notice again, the misapplication of the term "law," and the mistake concerning the idea which that term expresses in physics, whenever such idea is made to take the place of power, and, as such, to be assigned for the cause of anything, or of any property of anything, that exists. This is what we are secretly apt to do when we speak of organized bodies (plants, for instance, or animals) owing their production, their form, their growth, their quality, their beauty, their use, to any law or laws of nature; and when we are contented to sit down with that answer to our inquiries concerning them. I say once more that it is a perversion of language to assign any law as the efficient, operative cause of anything. A law presupposes an agent, for it only is the mode according to which an agent proceeds; it implies a power, for

* Ch. I., sect. vii.

it is the order according to which that power acts. Without this agent, without this power, which are both distinct from itself, the "law" does nothing, is nothing.

What has been said concerning "law" holds true of *mechanism*. Mechanism is not itself power. Mechanism, without power, can do nothing. Let a watch be contrived and constructed ever so ingeniously; be its parts ever so many, ever so complicated, ever so finely wrought or artificially put together, it cannot *go* without a weight or spring, *i. e.*, without a force independent of, and ulterior to, its mechanism. The spring, acting at the centre, will produce different motions and different results, according to the variety of the intermediate mechanism. One and the selfsame spring, acting in one and the same manner, *viz.*, by simply expanding itself, may be the cause of a hundred different and all useful movements, if a hundred different and well-devised sets of wheels be placed between it and the final effect; *e. g.*, may point out the hour of the day, the day of the month, the age of the moon, the position of the planets, the cycle of the years, and many other serviceable notices; and these movements may fulfil their purposes with more or less perfection, according as the mechanism is better or worse contrived, or better or worse executed, or in a better or worse state of repair: *but in all cases it is necessary that the spring act at the centre.* The course of our reasoning upon such a subject would be this: By inspecting the watch, even when standing still, we get a proof of contrivance, and of a contriving mind having been employed about it. In the form and obvious relations of its parts, we see enough to convince us of this. If we pull the works in pieces for the purpose of a closer examination, we are still more fully convinced. But, when we see the watch *going*, we see proof of another point, *viz.*, that there is a power somewhere, and somehow or other applied to it: a power in action; that there is more in the subject than the mere wheels of the machine; that there is a secret spring,

or a gravitating plummet; in a word, that there is force and energy as well as mechanism.

So, then, the watch in motion establishes to the observer two conclusions: One, that thought, contrivance, and design have been employed in the forming, proportioning, and arranging of its parts; and that whoever or whatever he be or were, such a contriver there is or was: The other, that force or power, distinct from mechanism, is at this present time acting upon it. If I saw a handmill even at rest, I should see contrivance; but if I saw it grinding, I should be assured that a hand was at the windlass, though in another room. It is the same in nature. In the works of nature we trace mechanism, and this alone proves contrivance: but living, active, moving, productive nature, proves also the exertion of a power at the centre; for wherever the power resides may be denominated the centre.

The intervention and disposition of what are called "*second causes*" fall under the same observation. This disposition is or is not mechanism, according as we can or cannot trace it by our senses and means of examination. That is all the difference there is; and it is a difference which respects our faculties, not the things themselves. Now, where the order of second causes is mechanical, what is here said of mechanism strictly applies to it. But it would be always mechanism (natural chymistry, for instance, would be mechanism) if our senses were acute enough to descry it. Neither mechanism, therefore, in the works of nature, nor the intervention of what are called second causes (for I think that they are the same thing), excuses the necessity of an agent distinct from both.

If, in tracing these causes, it be said that we find certain general properties of matter which have nothing in them that bespeaks intelligence, I answer that still the *managing* of these properties, the pointing and directing them to the uses which we see made of them, demands intelligence in the highest degree. For example: suppose animal secretions to

be elective attractions, and that such and such attractions universally belong to such and such substances, in all which there is no intellect concerned; still the choice and collocation of these substances, the fixing upon right substances, and disposing them in right places, must be an act of intelligence. What mischief would follow were there a single transposition of the secretory organs, a single mistake in arranging the glands which compose them!

There may be many second causes, and many courses of second causes, one behind another, between what we observe of nature and the Deity; but there must be intelligence somewhere; there must be more in nature than what we see, and, among the things unseen, there must be an intelligent, designing author. The philosopher beholds with astonishment the production of things around him. Unconscious particles of matter take their stations, and severally range themselves in an order, so as to become collectively plants or animals, *i. e.*, organized bodies, with parts bearing strict and evident relation to one another, and to the utility of the whole; and it should seem that these particles could not move in any other way than as they do, for they testify not the smallest sign of choice, or liberty, or discretion. There may be particular intelligent beings guiding these motions in each case, or they may be the result of trains of mechanical dispositions, fixed beforehand by an intelligent appointment, and kept in action by a power at the centre. But in either case there must be intelligence.

The minds of most men are fond of what they call a *principle*, and of the appearance of simplicity in accounting for phenomena. Yet this principle, this simplicity, resides merely in the *name;* which name, after all, comprises, perhaps, under it a diversified, multifarious, or progressive operation, distinguishable into parts. The power, in organized bodies, of producing bodies like themselves, is one of these principles. Give a philosopher this, and he can get on. But he does not reflect what this mode of production,

this principle (if such he choose to call it) requires; how much it presupposes; what an apparatus of instruments, some of which are strictly mechanical, is necessary to its success; what a train it includes of operations and changes, one succeeding another, one ministering to another; all advancing, by intermediate and, frequently, by sensible steps, to their ultimate result! Yet, because the whole of this complicated action is wrapped up in a single term, *generation*, we are to set it down as an elementary principle, and to suppose that, when we have resolved the things which we see into this principle, we have sufficiently accounted for their origin, without the necessity of a designing, intelligent Creator. The truth is, generation is not a principle, but a *process*. We might as well call the casting of metals a principle; we might, so far as appears to me, as well call spinning and weaving principles: and then, referring the texture of cloths, the fabric of muslins and calicoes, the patterns of diapers and damasks, to these as principles, pretend to dispense with intention, thought, and contrivance on the part of the artist, or to dispense, indeed, with the necessity of any artist at all, either in the manufacturing of the article or in the fabrication of the machinery by which the manufacture was carried on.

And, after all, how or in what sense is it true, that animals produce their *like*? A butterfly, with a proboscis instead of a mouth, with four wings and six legs, produces a hairy caterpillar, with jaws, and teeth, and fourteen feet. A frog produces a tadpole. A black beetle, with gauze wings and a crusty covering, produces a white, smooth, soft worm; an ephemeron fly a cod-bait maggot. These, by a progress through different stages of life, and action, and enjoyment (and in each state provided with implements and organs appropriated to the temporary nature which they bear), arrive at last at the form and fashion of the parent animal. But all this is process, not principle; and proves, moreover, that the property of animated bodies, of producing their like, be-

longs to them, not as a primordial property, not by any blind necessity in the nature of things, but as the effect of economy, wisdom, and design; because the property itself assumes diversities, and submits to deviations dictated by intelligible utilities, and serving distinct purposes of animal happiness.

The opinion which would consider "generation" as a *principle* in nature, and which would assign this principle as the cause, or endeavour to satisfy our minds with such a cause of the existence of organized bodies, is confuted, in my judgment, not only by every mark of contrivance discoverable in those bodies, for which it gives us no contriver, offers no account whatever; but also by the farther consideration that things generated possess a clear relation to things *not* generated. If it were merely one part of a generated body bearing a relation to another part of the same body, as the mouth of an animal to the throat, the throat to the stomach, the stomach to the intestines, those to the recruiting of the blood, and, by means of the blood, to the nourishment of the whole frame: or if it were only one generated body bearing a relation to another generated body, as the sexes of the same species to each other, animals of prey to their prey, herbivorous and granivorous animals to the plants or seeds upon which they feed, it might be contended that the whole of this correspondence was attributable to generation, the common origin from which these substances proceeded. But what shall we say to agreements which exist between things generated and things *not generated?* Can it be doubted, was it ever doubted, but that the *lungs* of animals bear a relation to the *air* as a permanently elastic fluid? They act in it and by it; they cannot act without it. Now, if generation produced the animal, it did not produce the air: yet their properties correspond. The *eye* is made for *light*, and light for the eye. The eye would be of no use without light, and light, perhaps, of little without eyes; yet one is produced by generation, the other not. The *ear* depends upon *undulations* of air. Here are two sets of

motions; first, of the pulses of the air; secondly, of the drum, bones, and nerves of the ear; sets of motions bearing an evident reference to each other: yet the one, and the apparatus for the one, produced by the intervention of generation, the other altogether independent of it.

If it be said that the air, the light, the elements, the world itself, is *generated*, I answer, that I do not comprehend the proposition. If the term mean anything similar to what it means when applied to plants or animals, the proposition is certainly without proof: and, I think, draws as near to absurdity as any proposition can do which does not include a contradiction in its terms. I am at a loss to conceive how the formation of the world can be compared to the generation of an animal. If the term generation signify something quite different from what it signifies on ordinary occasions, it may, by the same latitude, signify anything. In which case, a word or phrase taken from the language of Otaheite would convey as much theory concerning the origin of the universe as it does to talk of its being generated.

We know a cause (intelligence) adequate to the appearances which we wish to account for: we have this cause continually producing similar appearances: yet, rejecting this cause, the sufficiency of which we know, and the action of which is constantly before our eyes, we are invited to resort to suppositions destitute of a single fact for their support, and confirmed by no analogy with which we are acquainted. Were it necessary to inquire into the *motives* of men's opinions, I mean their motives separate from their arguments, I should almost suspect, that, because the proof of a Deity drawn from the constitution of nature is not only popular, but vulgar (which may arise from the cogency of the proof, and be, indeed, its highest recommendation), and because it is a species almost of *puerility* to take up with it; for these reasons, minds, which are habitually in search of invention and originality, feel a resistless inclination to strike off into other solutions and other expositions. The truth is,

that many minds are not so indisposed to anything which can be offered to them, as they are to the *flatness* of being content with common reasons: and, what is most to be lamented, minds conscious of superiority are the most liable to this repugnance.

The "suppositions" here alluded to all agree in one character: they all endeavour to dispense with the necessity in nature of a particular personal intelligence; that is to say, with the exertion of an intending, contriving mind, in the structure and formation of the organized constitutions which the world contains. They would resolve all productions into *unconscious* energies, of a like kind, in that respect, with attraction, magnetism, electricity, &c., without anything farther.

In this the old system of atheism and the new agree. And I much doubt whether the new schemes have advanced anything upon the old, or done more than changed the terms of the nomenclature. For instance, I could never see the difference between the antiquated system of atoms and Buffon's organic molecules. This philosopher, having made a planet by knocking off from the sun a piece of melted glass, in consequence of the stroke of a comet, and having set it in motion, by the same stroke, both round its own axis and the sun, finds his next difficulty to be, how to bring plants and animals upon it. In order to solve this difficulty, we are to suppose the universe replenished with particles, endowed with life, but without organization or senses of their own; and endowed also with a tendency to marshal themselves into organized forms. The concourse of these particles, by virtue of this tendency, but without intelligence, will, or direction (for I do not find that any of these qualities are ascribed to them), has produced the living forms which we now see.

Very few of the conjectures which philosophers hazard upon these subjects have more of pretension in them than the challenging you to show the direct impossibility of the hypothesis. In the present example, there seemed to be a positive objection to the

whole scheme upon the very face of it; which was, that if the case were as here represented, *new* combinations ought to be perpetually taking place; new plants and animals, or organized bodies which were neither, ought to be starting up before our eyes every day. For this, however, our philosopher has an answer. While so many forms of plants and animals are already in existence, and, consequently, so many "internal moulds," as he calls them, are prepared and at hand, the organic particles run into these moulds, and are employed in supplying an accession of substance to them, as well for their growth as for their propagation. By which means things keep their ancient course. But, says the same philosopher, should any general loss or destruction of the present constitution of organized bodies take place, the particles, for want of "moulds" into which they might enter, would run into different combinations, and replenish the waste with new species of organized substances.

Is there any history to countenance this notion? Is it known that any destruction has been so repaired? any desert thus repeopled?

So far as I remember, the only natural appearance mentioned by our author, by way of fact whereon to build his hypothesis, is the formation of *worms* in the intestines of animals, which is here ascribed to the coalition of superabundant organic particles, floating about in the first passages, and which have combined themselves into these simple animal forms, for want of internal moulds, or of vacancies in those moulds, into which they might be received. The thing referred to is rather a species of facts than a single fact, as some other cases may, with equal reason, be included under it. But to make it a fact at all, or in any sort applicable to the question, we must begin with asserting an *equivocal* generation, contrary to analogy, and without necessity: contrary to an analogy, which accompanies us to the very limits of our knowledge or inquiries; for wherever, either in plants or animals, we are able to examine the subject, we find procreation from a parent form: without neces-

sity; for I apprehend that it is seldom difficult to suggest methods by which the eggs, or spawn, or yet invisible rudiments of these vermin, may have obtained a passage into the cavities in which they are found.* Add to this, that their *constancy to their species*, which, I believe, is as regular in these as in the other vermes, decides the question against our philosopher, if, in truth, any question remained upon the subject.

Lastly: these wonder-working instruments, these "internal moulds," what are they after all? what, when examined, but a name without a signification; unintelligible, if not self-contradictory; at the best, differing in nothing from the "essential forms" of the Greek philosophy? One short sentence of Buffon's work exhibits his scheme as follows: "When this nutritious and prolific matter, which is diffused throughout all nature, passes through the *internal mould* of an animal or vegetable, and finds a proper matrix or receptacle, it gives rise to an animal or vegetable of the same species." Does any reader annex a meaning to the expression "internal mould" in this sentence? Ought it, then, to be said, that, though we have little notion of an internal mould, we have not much more of a designing mind? The very contrary of this assertion is the truth. When we speak of an artificer or an architect, we talk of what is comprehensible to our understanding and familiar to our experience. We use no other terms than what refer us for their meaning to our consciousness and observation, what express the constant objects of both; whereas names like that we have mentioned refer us to nothing, excite no idea, convey a sound to the ear, but, I think, do no more.

Another system which has lately been brought forward, and with much ingenuity, is that of *appetencies*. The principle, and the short account of the theory,

* I trust I may be excused for not citing, as another fact which is to confirm the hypothesis, a grave assertion of this writer, that the branches of trees upon which the stag feeds break out again in his horns. Such *facts* merit no discussion.—(*Note of the Author.*)

is this: Pieces of soft, ductile matter, being endued with propensities or appetencies for particular actions, would, by continual endeavours, carried on through a long series of generations, work themselves gradually into suitable forms, and at length acquire, though perhaps by obscure and almost imperceptible improvements, an organization fitted to the action which their respective propensities led them to exert. A piece of animated matter, for example, that was endued with a propensity to *fly*, though ever so shapeless, though no other, we will suppose, than a round ball to begin with, would, in a course of ages, if not in a million of years, perhaps in a hundred millions of years (for our theorists, having eternity to dispose of, are never sparing in time), acquire *wings*. The same tendency to locomotion in an aquatic animal, or, rather, in an animated lump, which might happen to be surrounded by water, would end in the production of *fins;* in a living substance, confined to the solid earth, would put out *legs* and *feet;* or, if it took a different turn, would break the body into ringlets, and conclude by *crawling* upon the ground.

Although I have introduced the mention of this theory into this place, I am unwilling to give to it the name of an *atheistic* scheme for two reasons: first, because, so far as I am able to understand it, the original propensities and the numberless varieties of them (so different, in this respect, from the laws of mechanical nature), are, in the plan itself, attributed to the ordination and appointment of an intelligent and designing Creator; secondly, because, likewise, that large postulatum, which is all along assumed and presupposed, the faculty in living bodies of producing other bodies organized like themselves, seems to be referred to the same cause; at least, is not attempted to be accounted for by any other. In one important respect, however, the theory before us coincides with atheistic systems, viz., in that, in the formation of plants and animals, in the structure and use of their parts, it does away final causes.[62] In-

[62] In one sense, this doctrine (if it deserves the name) of appe-

stead of the parts of a plant or animal, or the particular structure of the parts, having been intended for the action or the use to which we see them applied; according to this theory, they have themselves grown out of that action, sprung from that use. The theory, therefore, dispenses with that which we insist upon, the necessity, in each particular case, of an intelligent, designing mind, for the contriving and determining of the forms which organized bodies bear. Give our philosopher these appetencies; give him a portion of living irritable matter (a nerve, or the clipping of a nerve) to work upon; give also to his incipient or progressive forms the power, in every stage, of their alteration, of propagating their like; and, if he is to be believed, he could replenish the world with all the vegetable and animal productions which we at present see in it.

The scheme under consideration is open to the same objection with other conjectures of a similar tendency, *viz.*, a total defect of evidence. No changes like those which the theory requires have ever been observed. All the changes in Ovid's Metamorphoses might have been effected by these appetencies if the theory were true; yet not an example, nor the pretence of an example, is offered of a single change being known to have taken place. Nor is the order of generation obedient to the principle upon which this theory is built. The mammæ* of the male have not

tencies can hardly be said to supersede final causes. For suppose the *conatus* or appetency to have formed an eye, such as we now have it, and constructed as we know it to be, all its uses continue; it is calculated to perform the office required, to supply that, the desire of supplying which is supposed to have produced it. Stating that desire caused the production appears only to be a covert and somewhat absurd mode of stating the doctrine of final causes.

* I confess myself totally at a loss to guess at the reason, either final or efficient, for this part of the animal frame: unless there be some foundation for an opinion, of which I draw the hint from a paper of Mr Everard Home (Phil. Transact. 1799, pt. 2), viz., that the mammæ of the fœtus may be formed before the sex is determined.*—(*Note of the Author.*)

* The paper alluded to is upon Hermaphrodites, in vol. lxxxix.,

vanished by inusitation; *nec curtorum, per multa sæcula, Judæorum propagini deest præputium.* It is easy to say, and it has been said, that the alterative process is too slow to be perceived; that it has been carried on through tracts of immeasurable time; and that the present order of things is the result of graduation, of which no human records can trace the steps. It is easy to say this; and yet it is still true, that the hypothesis remains destitute of evidence.

The *analogies* which have been alleged are of the following kind: The *bunch* of a camel is said to be no other than the effect of carrying burdens; a service in which the species has been employed from the most ancient times of the world. The first race, by the daily loading of the back, would probably find a small grumous tumour to be formed in the flesh of that part. The next progeny would bring this tumour into the world with them. The life to which they were destined would increase it. The cause which first generated the tubercle being continued, it would go on through every succession to augment its size, till it attained the form and the bulk under which it now appears. This may serve for one instance: another, and that also of the passive sort, is taken from certain species of birds. Birds of the *crane* kind, as the crane itself, the heron, bittern, stork, have, in general, their thighs bare of feathers. This privation is accounted for from the habit of wading in water, and from the effect of that element to check the growth of feathers upon these parts; in consequence of which, the health and vegetation of the feathers declined through each generation of the animal; the tender down, exposed to cold and wetness, became weak, and thin, and rare, till the deterioration ended in the result which we see, of absolute nakedness. I will mention a third instance, because it

p. 157, and the suggestion is in the remarks upon the want of ovaria in certain monstrous births, and the male parts being found instead. The author (Sir E. Home) suggests that this may be explained by supposing the ovium, before impregnation, to have been equally adapted to becoming either a male or a female fœtus.

is drawn from an active habit, as the last two were from passive habits; and that is the *pouch* of the pelican. The description which naturalists give of this organ is as follows: "From the lower edge of the under chap hangs a bag, reaching from the whole length of the bill to the neck, which is said to be capable of containing fifteen quarts of water. This bag the bird has a power of wrinkling up into the hollow of the under chap. When the bag is empty it is not seen: but when the bird has fished with success, it is incredible to what an extent it is often dilated. The first thing the pelican does in fishing is to fill the bag, and then it returns to digest its burden at leisure. The bird preys upon the large fishes, and hides them by dozens in its pouch. When the bill is opened to its widest extent, a person may run his head into the bird's mouth, and conceal it in this monstrous pouch, thus adapted for very singular purposes."* Now this extraordinary confirmation is nothing more, say our philosophers, than the result of habit; not of the habit or effort of a single pelican or of a single race of pelicans, but of a habit perpetuated through a long series of generations. The pelican soon found the convenience of reserving in its mouth, when its appetite was glutted, the remainder of its prey, which is fish. The fulness produced by this attempt, of course, stretched the skin which lies between the under chaps, as being the most yielding part of the mouth. Every distension increased the cavity. The original bird, and many generations which succeeded him, might find difficulty enough in making the pouch answer this purpose: but future pelicans, entering upon life with a pouch derived from their progenitors, of considerable capacity, would more readily accelerate its advance to perfection by frequently pressing down the sac with the weight of fish which it might now be made to contain.

These, or of this kind, are the analogies relied upon. Now, in the first place, the instances them-

* Goldsmith, vol. vi., p. 52.

selves are unauthenticated by testimony; and in theory, to say the least of them, open to great objections. Who ever read of camels without bunches, or with bunches less than those with which they are at present usually formed? A bunch not unlike the camel's is found between the shoulders of the buffalo; of the origin of which it is impossible to give the account here given. In the second example: Why should the application of water, which appears to promote and thicken the growth of feathers upon the bodies and breasts of geese, and swans, and other water-fowls, have divested of this covering the thighs of cranes? The third instance, which appears to me as plausible as any that can be produced, has this against it, that it is a singularity restricted to the species; whereas, if it had its commencement in the cause and manner which have been assigned, the like conformation might be expected to take place in other birds which feed upon fish. How comes it to pass that the pelican alone was the inventress, and her descendants the only inheritors of this curious resource?[63]

[63] The argument against the doctrine of *appetencies* may be urged thus upon well-known facts. If the camel's bunch has arisen from the animal, originally without any protuberance, having his back affected by burdens imposed, it would follow that human contrivance could alter the shape of beasts, which it most certainly cannot, as daily experience in regard to most domestic animals shows. No change of form produced immediately and directly, as by cutting, compressing, rubbing, can be perpetuated in the breed. All we can do with regard to animals, and all that any animals can do with regard to themselves, is indirectly, as by affecting their health, to affect the proportions of their parts, as bone, fat, muscle; the effects of which changes will be perceived in the progeny.

We have here been observing only upon the fact; but suppose the fact to be as the theory of appetencies assumes; suppose the camel's bunch has been formed by weight and friction, and the pelican's pouch by the food distending the underchap; in other words, suppose (contrary to what we have shown is the fact) that the changes induced in one animal or race at a given time, are propagated and continue in their descendants, it is plain that the skeptical argument gains nothing by this concession. For how are such changes continued? Only by the process of generation. Nay, how are they at first effected? By the operation of physical

But it is the less necessary to controvert the instances themselves, as it is a straining of analogy, beyond all limits of reason and credibility, to assert that birds, and beasts, and fish, with all their variety and complexity of organization, have been brought into their forms, and distinguished into their several kinds and natures, by the same process (even if that process could be demonstrated, or had it ever been actually noticed), as might seem to serve for the gradual generation of a camel's bunch or a pelican's pouch.

The solution, when applied to the works of nature *generally*, is contradicted by many of the phenomena, and totally inadequate to others. The *ligaments* or strictures by which the tendons are tied down at the angles of the joints, could, by no possibility, be formed by the motion or exercise of the tendons themselves; by an appetency exciting these parts into action; or by any tendency arising therefrom. The tendency is all the other way; the *conatus* in constant opposition to them. Length of time does not help the case at all, but the reverse. The *valves* also in the bloodvessels could never be formed in the manner which our theorist proposes. The blood, in its right and natural course, has no tendency to form them. When obstructed or refluent, it has the con-

laws; that is, by the constitution of matter. The quadruped's bunch and the bird's pouch, allowing the whole facts to be as the argument assumes it, are both originally formed and propagated afterward by the means of the qualities with which matter is endowed; and the inference of design is not affected by the step thus added to the process of reasoning. It can manifestly make no difference to that inference, whether we hold that the bird's pouch is provided for its necessities by a conformation at all times belonging to it according to the constitution of the world, or by one superinduced according to that same constitution. The utmost that the skeptical hypothesis can gain by such concessions as we have been supposing to be made, is that the form of the world was at one time less perfect than it now is. A similar remark arises upon the conjecture of La Place (in which others have followed him) respecting the original arrangement of the motions and longitudes of Jupiter's three first satellites, treated of in another note.—(*See notes to Chap.* xxii.)

trary. These parts could not grow out of their use, though they had eternity to grow in.

The *senses* of animals appear to me altogether incapable of receiving the explanation of their origin which this theory affords. Including under the word "sense" the organ and the perception, we have no account of either. How will our philosopher get at *vision*, or make an eye? How should the blind animal affect sight, of which blind animals, we know, have neither conception nor desire? Affecting it, by what operation of its will, by what endeavour to see, could it so determine the fluids of its body as to inchoate the formation of an eye? or, suppose the eye formed, would the perception follow? The same of the other senses. And this objection holds its force, ascribe what you will to the hand of time, to the power of habit, to changes too slow to be observed by man, or brought within any comparison which he is able to make of past things with the present; concede what you please to these arbitrary and unattested suppositions, how will they help you? Here is no inception. No laws, no course, no powers of nature which prevail at present, nor any analogous to these, would give commencement to a new sense. And it is in vain to inquire how that might proceed which could never *begin*.

I think the senses to be the most inconsistent with the hypothesis before us of any part of the animal frame. But other parts are sufficiently so. The solution does not apply to the parts of animals which have little in them of motion. If we could suppose joints and muscles to be gradually formed by action and exercise, what action or exercise could form a scull and fill it with brains? No effort of the animal could determine the clothing of its skin. What *conatus* could give prickles to the porcupine or hedgehog, or to the sheep its fleece?

In the last place: what do these appetencies mean when applied to plants? I am not able to give a signification to the term which can be transferred from animals to plants; or which is common to both.

Yet a no less successful organization is found in plants than what obtains in animals. A solution is wanted for one as well as the other.

Upon the whole, after all the schemes and struggles of a reluctant philosophy, the necessary resort is to a Deity. The marks of *design* are too strong to be got over. Design must have had a designer. That designer must have been a person. That person is God.

CHAPTER XXIV.

OF THE NATURAL ATTRIBUTES OF THE DEITY.[64]

It is an immense conclusion that there is a God; a perceiving, intelligent, designing Being; at the

[64] By *natural* attributes in this chapter the author probably means those attributes of the Deity which can be discerned by means of nature. As usually employed, the title stands for Divine Power, Wisdom, &c., as distinguished from attributes which indicate moral character, such as justice, veracity, and goodness. Of these last it will be perceived that the author makes no mention in this chapter; and in the following chapters he discusses but one of them, viz., Divine Benevolence. One reason for this omission may be found in the fact, that the clearest proofs of Divine Justice are to be gathered from our own moral constitution; a part of our nature to which he makes no reference. Another reason may have been, that, not regarding a sense of justice as one of the original principles in man's nature, he does not feel authorized to ascribe it to Him in whose image man was made. (See Paley's Mor. Phil., ch. v., b. i.) The omission must, in any event, be considered as a serious one, and ought to be supplied by the reader. Proofs of Divine Justice, Veracity, &c., can be gathered, 1st, from our moral constitution; 2d, from the various laws of nature, physical, organic, and intellectual, all of which seem to be so arranged as to favour virtue; 3d, from the course of Divine Providence. In connexion with these attributes, the question of a future state presents itself, and this will be found to receive from the author only incidental notices. The inquirer on this subject is referred to the first five chapters of the First Part of Butler's Analogy.—*Am. Ed.*

head of creation, and from whose will it proceeded. The *attributes* of such a Being, suppose his reality to be proved, must be adequate to the magnitude, extent, and multiplicity of his operations: which are not only vast beyond comparison with those performed by any other power, but, so far as respects our conceptions of them, infinite, because they are unlimited on all sides.

Yet the contemplation of a nature so exalted, however surely we arrive at the proof of its existence, overwhelms our faculties. The mind feels its powers sink under the subject. One consequence of which is, that from painful abstraction the thoughts seek relief in sensible images. Whence may be adduced the ancient and almost universal propensity to idolatrous substitutions.[65] They are the resources of a labouring imagination. False religions usually fall in with the natural propensity; true religions, or such as have derived themselves from the true, resist it.

It is one of the advantages of the revelations which we acknowledge, that, while they reject idolatry with its many pernicious accompaniments, they introduce the Deity to human apprehension, under an idea more personal, more determinate, more within its compass, than the theology of nature can do. And this they do by representing him exclusively under the relation in which he stands to ourselves; and, for the most part, under some precise character, resulting from that relation, or from the history of his providences: which method suits the span of our intellects much better than the universality which enters into the idea of God, as deduced from the views of nature. When,

[65] This propensity to idolatrous substitutions may be owing, also, to the disposition which the ignorant and inexperienced have to attribute life and activity to every object, to regard it as acting with its own rather than with a derived power. Hence the worship of the elements and of the heavenly bodies. It may also be observed in this connexion, though the remark belongs more properly to the next chapter, that, where *polytheism* has prevailed, it has been accompanied, usually, if not always, with a belief in one God who was supreme over all the rest.—*Am. Ed.*

therefore, these representations are well founded in point of authority (for all depends upon that), they afford a condescension to the state of our faculties of which they who have most reflected on the subject will be the first to acknowledge the want and the value.

Nevertheless, if we be careful to imitate the documents of our religion, by confining our explanations to what concerns ourselves, and do not affect more precision in our ideas than the subject allows of, the several terms which are employed to denote the attributes of the Deity may be made, even in natural religion, to bear a sense consistent with truth and reason, and not surpassing our comprehension.

These terms are, Omnipotence, omniscience, omnipresence, eternity, self-existence, necessary existence, spirituality.

"Omnipotence," "omniscence," "infinite" power, "infinite" knowledge, are *superlatives*, expressing our conception of these attributes in the strongest and most elevated terms which language supplies. We ascribe power to the Deity under the name of "omnipotence," the strict and correct conclusion being, that a power which could create such a world as this is, must be, beyond all comparison, greater than any which we experience in ourselves, than any which we observe in other visible agents: greater also than any which we can want, for our individual protection and preservation, in the Being upon whom we depend. It is a power, likewise, to which we are not authorized, by our observation or knowledge, to assign any limits of space or duration.

Very much of the same sort of remark is applicable to the term "omniscience," infinite knowledge, or infinite wisdom. In strictness of language, there is a difference between knowledge and wisdom; wisdom always supposing action, and action directed by it. With respect to the first, viz., *knowledge*, the Creator must know, intimately, the constitution and properties of the things which he created; which seems also to imply a foreknowledge of their action upon

one another, and of their changes; at least so far as the same result from trains of physical and necessary causes. His omniscience also, as far as respects things present, is deducible from his nature, as an intelligent being, joined with the extent, or, rather, the universality of his operations. Where he acts, he is: and where he is, he perceives. The *wisdom* of the Deity, as testified in the works of creation, surpasses all idea we have of wisdom, drawn from the highest intellectual operations of the highest class of intelligent beings with whom we are acquainted, and, which is of the chief importance to us, whatever be its compass or extent, which it is evidently impossible that we should be able to determine, it must be adequate to the conduct of that order of things under which we live. And this is enough. It is of very inferior consequence by what terms we express our notion, or, rather, our admiration of this attribute. The terms which the piety and the usage of language have rendered habitual to us, may be as proper as any other. We can trace this attribute much beyond what is necessary for any conclusion to which we have occasion to apply it. The degree of knowledge and power requisite for the formation of created nature cannot, with respect to us, be distinguished from infinite.[66]

[66] It is not, perhaps, quite correct to state that "*infinite*," as applied to the Deity, means only a degree of power or wisdom beyond all comparison greater than any such qualities possessed by ourselves; and that this term, as well as "*omnipotence*," is merely a superlative. Those words also designate the existence of the attributes in such a degree, that any extent whatever of them being either presented to our observation, or conceived by our imagination, the Deity possesses them in a still greater degree; a degree to which our conception can affix no bounds.*

* Conceptions of infinite space and eternal duration seem to be involved in our notions of body, and of succession or time (see Cousin's Psychology, ch. ii. and iii.). To use the words of Stewart, "they force themselves upon our belief," and hence, when we obtain by other means the notion of an Intelligent First Cause, we naturally connect with it these pre-existing ideas of immensity and eternity. In other words, we regard God as a being

The divine "omnipresence" stands, in natural theology, upon this foundation: In every part and place of the universe with which we are acquainted, we perceive the exertion of a power which we believe, mediately or immediately, to proceed from the Deity. For instance: in what part or point of space that has ever been explored do we not discover attraction? In what regions do we not find light! In what accessible portion of our globe do we not meet with gravity, magnetism, electricity, together with the properties also and powers of organized substances, of vegetable or of animated nature? Nay, farther, we may ask, what kingdom is there of nature, what corner of space, in which there is anything that can be examined by us, where we do not fall upon contrivance and design? The only reflection, perhaps, which arises in our minds from this view of the world around us is, that the laws of nature everywhere prevail; that they are uniform and universal. But what do you mean by the laws of nature, or by any law? Effects are produced by power, not by laws. A law cannot execute itself. A law refers us to an agent. Now an agency so general as that we cannot discover its absence, or assign the place in which some effect of its continued energy is not found, may, in popular language at least, and, perhaps, without much deviation from philosophical strictness, be called universal; and, with not quite the same, but with no inconsiderable propriety, the Person or Being in whom that power resides, or from whom it is derived, may be taken to be *omnipresent*. He who upholds all things by his power may be said to be everywhere present.

This is called a virtual presence. There is also what metaphysicians denominate an essential ubiquity, and which idea the language of Scripture seems

of *Infinite* perfections. The process seems to be intuitive. Another argument for the infinity of the Divine attributes, being a reply to the subtle doubts stated by Mr. Hume in his Essay on Providence and a Future State, will be found in Note V. to Lord Brougham's Preliminary Discourse.—*Am. Ed.*

to favour; but the former, I think, goes as far as natural theology carries us.[67]

"Eternity" is a negative idea, clothed with a positive name. It supposes, in that to which it is applied, a present existence, and is the negation of a beginning or an end of that existence. As applied to the Deity, it has not been controverted by those who acknowledge a Deity at all. Most assuredly there never was a time in which nothing existed, because that condition must have continued. The universal *blank* must have remained; nothing could rise up out of it; nothing could ever have existed since, nothing could exist now. In strictness, however, we have no concern with duration prior to that of the visible world. Upon this article, therefore, of theology, it is sufficient to know that the contriver necessarily existed before the contrivance.

"Self-existence" is another negative idea, viz., the negation of a preceding cause, as of a progenitor, a maker, an author, a creator.[68]

[67] Upon this confessedly abstruse subject the three doctrines are, ubiquity by *diffusion*, *virtual*; ubiquity, or that of power only; and ubiquity of *essence*. The last is expressed thus, to the exclusion of the second, by Sir I. Newton, in the Schol. Gen. to the Principia: "Omnipræsens est non per *virtutem* solam sed etiam per *substantiam*; nam virtus sine substantiâ subsistere non potest." It is, perhaps, hardly correct to say that natural theology carries us not to the idea of essential ubiquity. Dr. Clarke makes essential ubiquity one part of his conclusion from the argument *à priori*; and though his adversaries (see Chev. Ramsay, book i., prop. 8, Schol.) charged him with adopting the Diffusive Ubiquity, he is plainly not subject to this observation. The followers of Socinus, who maintained Virtual Ubiquity, are ably combated, and the Essential Ubiquity defended by Dr. Hancock (Boyle's Lectures, vol. ii., p. 222) upon arguments drawn from natural religion. We are here, it is to be observed, only speaking of the idea or doctrine, itself having been attained independent of Revelation; and not inquiring how far those arguments of unassisted reason have enforced the belief of it, or even made it comprehensible. Descartes (Principia, I., xxii.) does not enumerate Ubiquity at all among the attributes, unless in so far as it may be included under infinite perfection generally ascribed.—(I., xxii., xxvii.; II., xxxvi.; III., i.)

[68] *Self-existent* means, in any intelligible sense, only uncreated, independent, eternal. The ancient doctrine of *Self-created*, if it

"Necessary existence" means demonstrable existence.[69]

"Spirituality" expresses an idea made up of a negative part and of a positive part. The negative part consists in the exclusion of some of the known properties of matter, especially of solidity, of the *vis inertiæ*, and of gravitation. The positive part comprises perception, thought, will, power, *action*, by which last term is meant the origination of motion; the quality, perhaps, in which resides the essential superiority of spirit over matter, "which cannot move unless it be moved, and cannot but move when impelled by another."* I apprehend that there can be no difficulty in applying to the Deity both parts of this idea.

CHAPTER XXV.

OF THE UNITY OF THE DEITY.

Of the "Unity of the Deity," the proof is, the *uniformity* of plan observable in the universe. The universe itself is a system; each part either depending upon other parts, or being connected with other parts by some common law of motion, or by the presence of some common substance. One principle of gravitation causes a stone to drop towards the earth, and the moon to wheel round it. One law of attraction carries all the different planets about the sun.[70] This

goes beyond the mere negative sense, is absolutely unintelligible, or, to use Dr. Clarke's words, "an express contradiction."

[69] *Necessary* properly means demonstrable in such a way that the contrary involves a contradiction, and is inconceivable. Dr. Paley here uses the word demonstrable *per se* in this sense; for which he has the authority of several metaphysical writers.

* Bishop Wilkins's Principles of Natural Religion, p. 106.

[70] Bishop Brinkley considers the subject of nebulæ and double

philosophers demonstrate. There are also other points of agreement among them, which may be considered

stars "as hardly yet sufficiently investigated" for affording grounds of additional illustration to the cultivator of Natural Theology; and it is much to be regretted that he, on this account, abandoned the design, which he says he had at one time formed, of adding some notes upon this branch of astronomical science.*

The fact of the heavenly bodies which form our system all moving in the same direction of revolution, is deserving of the deepest attention when we consider that it leads to the most important result of the stability of the system explained above (chap. xxii., notes); and that it is one of innumerable arrangements which might have been made, and none of which could have led to this result. In any other case, equal roots, or imaginary roots, or both, must have found their way into the equation from which the law of stability is deduced.—(*Méc Cél.*, l. ii., c. 7, s. 55, 57, and liv. xv., c. 1.) Now the same profound geometrician has shown, in another work, by the calculus of probabilities, that it is above four millions of millions to one in favour of the forty-three motions from west to east (including rotation as well as revolution, and the motions of the sun and of the rings as well as the planets and satellites) having been directed by one original or First Cause; and by the same calculus he has shown the probability of the sun's rising again on the morrow of any given day, to be not much more than 1,800,000 to one; or, in other words, that this event is above two million times less probable than the truth of the position that the motions in our system were designed by one First Cause. This illustrious philosopher has been censured for not drawing in terms the conclusion to which his sublime researches, with those of Lagrange, have led the way, and at which he must himself have arrived; that a Supreme Intelligence alone could have formed this magnificent and stable system. His reason for abstaining from indulging in such contemplations probably was, that his

* To render this allusion intelligible, it may be proper to state, that, according to the observations and calculations of Sir John Herschel, several of the stars, called *double stars*, consist of a pair of luminous bodies, which revolve about each other in ellipses in such a manner as to show that the force by which they are attracted to each other varies according to the law of the inverse square. It would thus seem that the law of attraction, which prevails throughout the solar system, operates also at distances so great, that, when compared with them, the whole space occupied by that system shrinks into a point; and there seems to be no reason to doubt that it acts on all bodies in the universe. This constitutes a striking argument in favour of the Divine Unity, provided the calculations and observations above referred to can be relied on.—*Am. Ed.*

as marks of the identity of their origin and of their intelligent Author. In all are found the convenience and stability derived from gravitation. They all experience vicissitudes of days and nights, and changes of season. They all, at least Jupiter, Mars, and Venus, have the same advantages from their atmosphere as we have. In all the planets, the axes of rotation are permanent. Nothing is more probable than that the same attracting influence, acting according to the same rule, reaches to the fixed stars: but, if this be only probable, another thing is certain, *viz.*, that the same element of light does. The light from a fixed star affects our eyes in the same manner, is refracted and reflected according to the same laws as the light of a candle. The velocity of the light of the fixed stars is also the same as the velocity of the light of the sun, reflected from the satellites of Jupiter. The heat of the sun, in kind, differs nothing from the heat of a coal fire.[71]

work is purely mathematical, and that this would have been a digression into another science. But the reason is not sufficient, and the omission must ever be lamented as a defect in a work so nearly perfect. Mr. Whewell has made some ingenious strictures upon this subject in his able and learned *Bridgewater Treatise*, b. iii., c. 5 and 6.

[71] The law by which the distances of the planets are regulated was referred to in a note by Bishop Brinkley to the 22d chapter, and affords an evidence of unity of design not to be passed over. It is this nearly, but not exactly. Form a series of numbers, each consisting of the number 4 added to the number 3, but to the number 3 multiplied successively by 0, 1, 2, 4, 8, 16, and the other powers of 2: the mean distances of Mercury being 4, this series will represent the mean distance of the other planets successively. Taking the four newly-discovered planets between Mars and Jupiter as one, the distances of Venus, the Earth, and Jupiter coincide with the series exactly; the others slightly differ. Thus,

Mercury, by the supposition		4			4
Venus, by the theory		7	by observation		7
Earth		10			10
Mars		16			15
New planets		28			27
	Vesta	23·73			
	Juno	26·67			
	Ceres	27·67			
	Pallas	27·68			

In our own globe the case is clearer. New countries are continually discovered, but the old laws of nature are always found in them; new plants, perhaps, or animals, but always in company with plants and animals which we already know;[72] and always possessing many of the same general properties. We never get among such original, or totally different modes of existence, as to indicate that we are come into the province of a different Creator, or under the direction of a different will. In truth, the same order of things attends us wherever we go. The elements act upon one another, electricity operates, the tides rise and fall, the magnetic needle elects its position in one region of the earth and sea as well as in another. One atmosphere invests all parts of the globe, and connects all; one sun illuminates, one moon exerts its specific attraction upon all parts. If there be a variety in natural effects, as, *e. g.*, in the tides of different seas, that very variety is the result of the same cause, acting under different circumstances. In many cases this is proved; in all, is probable.

The inspection and comparison of *living* forms add to this argument examples without number. Of all large terrestrial animals the structure is very much alike; their senses nearly the same; their natural

Jupiter	. . . .	52	 52
Saturn	. . . .	100	 95
Uranus	. . . .	196	 192

"We cannot but remark," says Bishop Brinkley, "the near agreement of the law with the exact mean distances, and cannot hesitate to pronounce that those were assigned according to a law, although we are entirely ignorant of the exact law, and of the reason for that law."

This sentence derives a peculiar, though a painful interest, from the circumstance of its being in all likelihood the last written by this profound and accomplished astronomer on subjects connected with his favourite study. It closed the communication received from him, which was dated at Cloyne, June 25, 1835; and he died at Dublin in less than three months after (September 14).

[72] This remark requires some qualification, for there seem to be places where nearly all the animals or plants are peculiar. In St. Helena, for example, out of more than 60 native species, there are only two or three which have been found in other parts of the world.—*Am. Ed.*

functions and passions nearly the same; their viscera nearly the same, both in substance, shape, and office: digestion, nutrition, circulation, secretion, go on in a similar manner in all; the great circulating fluid is the same; for I think no difference has been discovered in the properties of *blood*, from whatever animal it be drawn. The experiment of transfusion proves that the blood of one animal will serve for another. The *skeleton* also of the larger terrestrial animals show particular varieties, but still under a great general affinity. The resemblance is somewhat less, yet sufficiently evident, between quadrupeds and birds. They are all alike in five respects for one in which they differ.

In *fish*, which belong to another department, as it were, of nature, the points of comparison become fewer. But we never lose sight of our analogy, *e. g.*, we still meet with a stomach, a liver, a spine; with bile and blood; with teeth; with eyes (which eyes are only slightly varied from our own, and which variation, in truth, demonstrates, not an interruption, but a continuance of the same exquisite plan: for it is the adaptation of the organ to the element, *viz.*, to the different refraction of light passing into the eye out of a denser medium). The provinces also, themselves of water and earth, are connected by the species of animals which inhabit both; and also by a large tribe of aquatic animals, which closely resemble the terrestrial in their internal structure; I mean the cetaceous tribe, which have hot blood, respiring lungs, bowels, and other essential parts, like those of land animals. This similitude, surely, bespeaks the same creation and the same Creator.

Insects and *shellfish** appear to me to differ from other classes of animals the most widely of any Yet even here, besides many points of particular resemblance, there exists a general relation of a peculiar kind. It is the relation of inversion; the law of contrariety: namely, that whereas, in other animals,

* See Bell on Shellfish.

the bones to which the muscles are attached lie *within* the body, in insects and shellfish they lie on the *outside* of it. The shell of a lobster performs to the animal the office of a *bone*, by furnishing to the tendons that fixed basis or immoveable fulcrum, without which, mechanically, they could not act. The crust of an insect is its shell, and answers the like purpose. The shell also of an oyster stands in the place of a *bone*; the bases of the muscles being fixed to it in the same manner as, in other animals, they are fixed to the bones. All which (under wonderful varieties, indeed, and adaptations of form) confesses an imitation, a remembrance, a carrying on of the same plan.

The observations here made are equally applicable to plants; but, I think, unnecessary to be pursued. It is a very striking circumstance, and also sufficient to prove all which we contend for, that in this part likewise of organized nature we perceive a continuation of the *sexual* system.

Certain however it is, that the whole argument for the divine unity goes no farther than to a unity of counsel.[73]

It may likewise be acknowledged, that no arguments which we are in possession of exclude the

[73] The extraordinary discoveries in geology made since Dr. Paley's time by the study of fossil osteology by no means impair his argument as to unity when rightly considered. [They present us with the fact that, before the earth assumed its present form and became the abode of men, it had been inhabited at different periods by many species of animals now extinct. An examination of the petrified bones of these animals shows that, though differing in many respects from existing species, they were in other respects strikingly analogous; thus indicating the presence of the same designing mind. For example, the intestines of the ichthyosaurus are proved to have been formed like an Archimedes' screw, so that the aliment, in passing through them, was exposed within the smallest space to the largest surface of absorbent vessels, and thus "drained of all its juices as we find in the digestive process of living animals. The similar structure of the intestinal canal in the shark and dogfish now existing has been noticed by naturalists, and our author expressly refers to it (chap. xvi., § 8) as making compensation by its spiral passage for its being straight and consequently short, compared with the intestinal passage in other animals."—*Am. Ed.*]

ministry of subordinate agents. If such there be, they act under a presiding, a controlling will; because they act according to certain general restrictions, by certain common rules, and, as it should seem, upon a general plan: but still such agents, and different ranks, and classes and degrees of them, may be employed.[74]

CHAPTER XXVI.

OF THE GOODNESS OF THE DEITY.

THE proof of the *divine goodness* rests upon two propositions: each, as we contend, capable of being made out by observations drawn from the appearances of nature.

The first is, "that in a vast plurality of instances in which contrivance is perceived, the design of the contrivance is *beneficial*."

The second, "that the Deity has superadded *pleasure* to animal sensations, beyond what was necessary for any other purpose, or when the purpose, so far as it was necessary, might have been effected by the operation of pain."

First, "in a vast plurality of instances in which

[74] Addison, a person of practical understanding, calm temperament, and widely removed from all enthusiasm (Spectator, No. 100), states very plainly his belief in spirits, not in the religious and philosophical sense of subordinate agents, adopted by Dr. Paley, but in the popular sense of ghosts. He rests his opinion, as Dr. Johnson did his strong inclination towards the same belief, upon the cogency of testimony. Respecting witchcraft, he elsewhere (No. 117) expresses the inclination of his opinion in favour of it generally and abstractedly; but refusing all credit to particular instances. The feeling which dictates such a disposition to believe in a spiritual world is natural as well as amiable. But it may be questioned if religion does not lose as much as it can gain by indulging in it.

contrivance is perceived, the design of the contrivance is *beneficial*."

No productions of nature display contrivance so manifestly as the parts of animals; and the parts of animals have all of them, I believe, a real, and, with very few exceptions, all of them a known and intelligible subservience to the use of the animal. Now, when the multitude of animals is considered, the number of parts in each, their figure and fitness, the faculties depending upon them, the variety of species, the complexity of structure, the success, in so many cases, and felicity of the result, we can never reflect, without the profoundest adoration, upon the character of that Being from whom all these things have proceeded: we cannot help acknowledging what an exertion of benevolence creation was; of a benevolence how minute in its care, how vast in its comprehension!

When we appeal to the parts and faculties of animals, and to the limbs and senses of animals in particular, we state, I conceive, the proper medium of proof for the conclusion which we wish to establish. I will not say that the insensible parts of nature are made solely for the sensitive parts: but this I say, that, when we consider the benevolence of the Deity, we can only consider it in relation to sensitive being. Without this reference, or referred to anything else, the attribute has no object; the term has no meaning. Dead matter is nothing. The parts, therefore, especially the limbs and senses of animals, although they constitute, in mass and quantity, a small portion of the material creation, yet, since they alone are instruments of perception, they compose what may be called the whole of visible nature, estimated with a view to the disposition of its Author. Consequently, it is in *these* that we are to seek his character. It is by these that we are to prove that the world was made with a benevolent design.[75]

[75] The benevolence of the Deity can be considered, of course, "only in reference to sensitive beings," but it can manifest it-

Nor is the design abortive. It is a happy world after all. The air, the earth, the water teem with delighted existence. In a spring noon or a summer evening, on whichever side I turn my eyes, myriads of happy beings crowd upon my view. "The insect youth are on the wing." Swarms of newborn *flies* are trying their pinions in the air. Their sportive motions, their wanton mazes, their gratuitous activity, their continual change of place without use or purpose, testify their joy, and the exultation which they feel in their lately-discovered faculties. A *bee* among the flowers in spring is one of the most cheerful objects that can be looked upon. Its life appears to be all enjoyment; so busy and so pleased; yet it is only a specimen of insect life, with which, by reason of the animal being half domesticated, we happen to be better acquainted than we are with that of others. The *whole-winged* insect tribe, it is probable, are equally intent upon their proper employments, and, under every variety of constitution, gratified, and perhaps equally gratified, by the offices which the Author of their nature has assigned to them. But the atmosphere is not the only scene of enjoyment for the insect race. Plants are covered with aphides greedily sucking their juices, and constantly, as it should seem, in the act of sucking. It cannot be doubted but that this is a state of gratification. What else should fix them so close to the operation, and so long? Other species are *running about*, with an alacrity in their motions which carries with it every mark of pleasure. Large patches of ground are sometimes half covered with these brisk and sprightly natures. If we look to what the *waters* produce, shoals of the fry of fish frequent the margins of rivers, of lakes, and

self in the properties and laws which He gives to "dead matter," as well as in "the limbs and senses of animals." Any law, mechanical or chymical, which can be shown to contribute materially to the welfare and enjoyment of living beings, is an evidence of a benevolent disposition in the Author of Nature. See the author's own chapters on the Elements and on Astronomy.—*Am. Ed.*

of the sea itself. These are so happy that they know not what to do with themselves. Their attitudes, their vivacity, their leaps out of water, their frolics in it (which I have noticed a thousand times with equal attention and amusement), all conduce to show their excess of spirits, and are simply the effects of that excess. Walking by the seaside in a calm evening, upon a sandy shore and with an ebbing tide, I have frequently remarked the appearance of a dark cloud, or, rather, very thick mist, hanging over the edge of the water, to the height, perhaps, of half a yard, and of the breadth of two or three yards, stretching along the coast as far as the eye could reach, and always retiring with the water. When this cloud came to be examined, it proved to be nothing else than so much space filled with young *shrimps*, in the act of bounding into the air from the shallow margin of the water or from the wet sand. If any motion of a mute animal could express delight, it was this: if they had meant to make signs of their happiness, they could not have done it more intelligibly. Suppose, then, what I have no doubt of, each individual of this number to be in a state of positive enjoyment; what a sum, collectively, of gratification and pleasure have we here before our view![76]

The *young* of all animals appear to me to receive pleasure simply from the exercise of their limbs and bodily faculties, without reference to any end to be attained, or any use to be answered by the exertion. A child, without knowing anything of the use of language, is in a high degree delighted with being able to speak. Its incessant repetition of a few articulate sounds, or, perhaps, of the single word which it has learned to pronounce, proves this point clearly. Nor is it less pleased with its first successful endeavours to walk, or, rather, to run (which precedes walk-

[76] To these considerations it must be added, that the lives of such animals may be only apparently short. If time is but the succession of ideas, then, as Soame Jenyns has observed, the insect that flutters for a single summer's day may in reality live as long as the tortoise that breathes for a century.

ing), although entirely ignorant of the importance of the attainment to its future life, and even without applying it to any present purpose. A child is delighted with speaking, without having anything to say, and with walking, without knowing where to go. And, prior to both these, I am disposed to believe that the waking hours of infancy are agreeably taken up with the exercise of vision, or, perhaps, more properly speaking, with learning to see.

But it is not for youth alone that the great Parent of creation hath provided. Happiness is found with the purring cat no less than with the playful kitten; in the arm-chair of dozing age, as well as in either the sprightliness of the dance or the animation of the chase. To novelty, to acuteness of sensation, to hope, to ardour of pursuit, succeeds what is, in no inconsiderable degree, an equivalent for them all, "perception of ease." Herein is the exact difference between the young and the old. The young are not happy but when enjoying pleasure; the old are happy when free from pain. And this constitution suits with the degrees of animal power which they respectively possess. The vigour of youth was to be stimulated to action by impatience of rest; while to the imbecility of age, quietness and repose become positive gratifications. In one important respect the advantage is with the old. A state of ease is, generally speaking, more attainable than a state of pleasure. A constitution, therefore, which can enjoy ease, is preferable to that which can taste only pleasure. This same perception of ease oftentimes renders old age a condition of great comfort; especially when riding at its anchor after a busy or tempestuous life. It is well described by Rousseau to be the interval of repose and enjoyment between the hurry and the end of life. How far the same cause extends to other animal natures cannot be judged of with certainty. The appearance of satisfaction with which most animals, as their activity subsides, seek and enjoy rest, affords reason to believe that this source of gratification is appointed to advanced life,

under all or most of its various forms. In the species with which we are best acquainted, namely, our own, I am far, even as an observer of human life, from thinking that youth is its happiest season, much less the only happy one: as a Christian, I am willing to believe that there is a great deal of truth in the following representation given by a very pious writer as well as excellent man:* "To the intelligent and virtuous, old age presents a scene of tranquil enjoyments, of obedient appetite, of well-regulated affections, of maturity in knowledge, and of calm preparation for immortality. In this serene and dignified state, placed, as it were, on the confines of two worlds, the mind of a good man reviews what is past with the complacency of an approving conscience; and looks forward, with humble confidence in the mercy of God, and with devout aspirations towards his eternal and ever-increasing favour."

What is seen in different stages of the same life, is still more exemplified in the lives of different animals. Animal enjoyments are infinitely *diversified*. The modes of life to which the organization of different animals respectively determines them, are not only of various but of opposite kinds. Yet each is happy in its own. For instance, animals of prey live much alone; animals of a milder constitution in society. Yet the herring, which lives in shoals, and the sheep, which lives in flocks, are not more happy in a crowd, or more contented among their companions, than is the pike or the lion with the deep solitudes of the pool or the forest.

But it will be said that the instances which we have here brought forward, whether of vivacity or repose, or of apparent enjoyment derived from either, are picked and favourable instances. We answer, first, that they are instances, nevertheless, which comprise large provinces of sensitive existence; that every case which we have described is the case of millions. At this moment, in every given moment of time, how

* Father's Instructions, by Dr. Percival, of Manchester, p. 317.

many myriads of animals are eating their food, gratifying their appetites, ruminating in their holes, accomplishing their wishes, pursuing their pleasures, taking their pastimes! In each individual, how many things must go right for it to be at ease; yet how large a proportion out of every species is so in every assignable instant! Secondly, we contend, in the terms of our original proposition, that throughout the whole of life, as it is diffused in nature, and as far as we are acquainted with it, looking to the average of sensations, the plurality and the preponderance is in favour of happiness by a vast excess. In our own species, in which, perhaps, the assertion may be more questionable than any other, the prepollency of good over evil, of health, for example, and ease, over pain and distress, is evinced by the very notice which calamities excite. What inquiries does the sickness of our friends produce! what conversation their misfortunes! This shows that the common course of things is in favour of happiness; that happiness is the rule, misery the exception. Were the order reversed, our attention would be called to examples of health and competence instead of disease and want.

One great cause of our insensibility to the goodness of the Creator is the very *extensiveness* of his bounty. We prize but little what we share only in common with the rest, or with the generality of our species. When we hear of blessings, we think forthwith of successes, of prosperous fortunes, of honours, riches, preferments, *i. e.*, of those advantages and superiorities over others which we happen either to possess, or to be in pursuit of, or to covet. The common benefits of our nature entirely escape us. Yet these are the great things. These constitute what most properly ought to be accounted blessings of Providence; what alone, if we might so speak, are worthy of its care. Nightly rest and daily bread, the ordinary use of our limbs, and senses, and understandings, are gifts which admit of no comparison with any other. Yet, because almost every man we meet with possesses these, we leave them out of our

enumeration. They raise no sentiment, they move no gratitude. Now herein is our judgment perverted by our selfishness. A blessing ought in truth to be the *more* satisfactory, the bounty at least of the donor is rendered more conspicuous, by its very diffusion, its commonness, its cheapness; by its falling to the lot, and forming the happiness of the great bulk and body of our species, as well as of ourselves. Nay, even when we do not possess it, it ought to be matter of thankfulness that others do. But we have a different way of thinking. We court distinction. That is not the worst: we *see* nothing but what has distinction to recommend it. This necessarily contracts our views of the Creator's beneficence within a narrow compass, and most unjustly. It is in those things which are so common as to be no distinction that the amplitude of the Divine benignity is perceived.

But pain, no doubt, and privations exist, in numerous instances and to a great degree, which collectively would be very great if they were compared with any other thing than with the mass of animal fruition. For the application, therefore, of our proposition to that *mixed* state of things which these exceptions induce, two rules are necessary, and both, I think, just and fair rules. One is, that we regard those effects alone which are accompanied with proofs of intention: the other, that, when we cannot resolve all appearances into benevolence of design, we make the few give place to the many, the little to the great; that we take our judgment from a large and decided preponderance, if there be one.[77]

[77] This passage, with others which afterward occur in this work, as well as the part here quoted from the author's Moral Philosophy, has been, it should seem, somewhat misunderstood by several excellent authors, who have treated him as if he were denying the existence of evil, and have referred, though without any skeptical view, to the old dilemma of the Epicureans stated by Lactantius: "Aut vult, et non potest; aut potest, et non vult tollere mala." But Dr. Paley's whole discourse upon this subject must be taken as an attempt, and a successful one, to diminish the apparent amount of evil, by showing that many of the things accounted evils are less bad than they seem to be. He explains

I crave leave to transcribe into this place what I have said upon this subject in my Moral Philosophy:

"When God created the human species, either he wished their happiness, or he wished their misery, or he was indifferent and unconcerned about either.

"If he had wished our misery, he might have made sure of his purpose by forming our senses to be so many sores and pains to us as they are now instruments of gratification and enjoyment, or by placing us amid objects so ill-suited to our perceptions as to have continually offended us, instead of ministering to our refreshment and delight. He might have made, for example, everything we tasted bitter, everything we saw loathsome, everything we touched a sting, every smell a stench, and every sound a discord.

"If he had been indifferent about our happiness or misery, we must impute to our good fortune (as all design by this supposition is excluded) both the capacity of our senses to receive pleasure, and the supply of external objects fitted to produce it.

"But either of these, and, still more, both of them, being too much to be attributed to accident, nothing remains but the first supposition, that God, when he created the human species, wished their happiness, and made for them the provision which he has made with that view and for that purpose.

"The same argument may be proposed in different terms; thus: Contrivance proves design, and the predominant tendency of the contrivance indicates the disposition of the designer. The world abounds with contrivances, and all the contrivances which we are acquainted with are directed to beneficial purposes.

the deductions which are fairly to be made; he shows the compensations which exist; he proves that out of evil good frequently arises. Having done this, evil still remains, but in an amount exceedingly reduced; and this remaining portion is that concerning which alone the question arises. All that follows of the text must be read with this view, and it must be admitted that nothing can be more legitimate than the scope of the reasoning employed, if regarded in this light. Viewed in any other, it would be liable to the objections which have been urged against it.

Evil no doubt exists, but is never, that we can perceive, the *object* of contrivance. Teeth are contrived to eat, not to ache; their aching now and then is incidental to the contrivance, perhaps inseparable from it: or even, if you will, let it be called a defect in the contrivance, but it is not the object of it. This is a distinction which well deserves to be attended to. In describing implements of husbandry, you would hardly say of the sickle that it is made to cut the reaper's hand; though, from the construction of the instrument and the manner of using it, this mischief often follows. But if you had occasion to describe instruments of torture or execution, this engine, you would say, is to extend the sinews; this to dislocate the joints; this to break the bones; this to scorch the soles of the feet. Here pain and misery are the very objects of the contrivance. Now nothing of this sort is to be found in the works of nature. We never discover a train of contrivance to bring about an evil purpose. No anatomist ever discovered a system of organization calculated to produce pain and disease, or, in explaining the parts of the human body, ever said, this is to irritate, this to inflame; this duct is to convey the gravel to the kidneys, this gland to secrete the humour which forms the gout: if by chance he come at a part of which he knows not the use, the most he can say is that it is useless; no one ever suspects that it is put there to incommode, to annoy, or to torment."

The TWO CASES which appear to me to have the most difficulty in them, as forming the most of the appearance of exception to the representation here given, are those of *venomous* animals and of animals *preying* upon one another. These properties of animals, wherever they are found, must, I think, be referred to design; because there is in all cases of the first, and in most cases of the second, an express and distinct organization provided for the producing of them. Under the first head, the fangs of vipers, the stings of wasps and scorpions, are as clearly intended for their purpose as any animal structure is for

any purpose the most incontestably beneficial. And the same thing must, under the second head, be acknowledged of the talons and beaks of birds; of the tusks, teeth, and claws of beasts of prey; of the shark's mouth, of the spider's web, and of numberless weapons of offence belonging to different tribes of voracious insects. We cannot, therefore, avoid the difficulty by saying that the effect was not intended. The only question open to us is whether it be ultimately evil. From the confessed and felt imperfection of our knowledge, we ought to presume, that there may be consequences of this economy which are hidden from us: from the benevolence which pervades the general designs of nature, we ought also to presume that these consequences, if they could enter into our calculations, would turn the balance on the favourable side. Both these I contend to be reasonable presumptions. Not reasonable presumptions, if these two cases were the only cases which nature presented to our observation, but reasonable presumptions under the reflection that the cases in question are combined with a multitude of intentions, all proceeding from the same author, and all, except these, directed to ends of undisputed utility. Of the vindications, however, of this economy which we are able to assign, such as most extenuate the difficulty are the following:

With respect to *venomous* bites and stings it may be observed:

1. That, the animal itself being regarded, the faculty complained of is *good*, being conducive, in all cases, to the defence of the animal; in some cases to the subduing of its prey, and in some, probably, to the killing of it, when caught, by a mortal wound, inflicted in the passage to the stomach, which may be no less merciful to the victim than salutary to the devourer. In the viper, for instance, the poisonous fang may do that which in other animals of prey is done by the crush of the teeth. Frogs and mice might be swallowed alive without it.

2 But it will be said that this provision, when it

comes to the case of bites, deadly even to human bodies, and to those of large quadrupeds, is greatly *overdone*, that it might have fulfilled its use, and yet have been much less deleterious than it is. Now I believe the case of bites which produce death in large animals (of stings I think there are none) to be very few. The experiments of the Abbé Fontana, which were numerous, go strongly to the proof of this point. He found that it required the action of five exasperated vipers to kill a dog of moderate size; but that, to the killing of a mouse or a frog, a single bite was sufficient, which agrees with the use which we assign to the faculty. The abbé seemed to be of opinion, that the bite even of the rattlesnake would not usually be mortal; allowing, however, that in certain particularly unfortunate cases, as when the puncture had touched some very tender part, pricked a principal nerve, for instance, or, as it is said, some more considerable lymphatic vessel, death might speedily ensue.

3. It has been, I think, very justly remarked concerning serpents, that, while only a few species possess the venomous property, that property guards the whole tribe. The most innocuous snake is avoided with as much care as a viper. Now the terror with which large animals regard this class of reptiles is its protection, and this terror is founded on the formidable revenge which a few of the number, compared with the whole, are capable of taking. The species of serpents described by Linnæus amount to two hundred and eighteen, of which thirty-two only are poisonous.

4. It seems to me that animal constitutions are provided, not only for each element, but for each state of the elements, *i. e.*, for every climate and for every temperature: and that part of the mischief complained of arises from animals (the human animals most especially) occupying situations upon the earth which do not belong to them, nor were ever intended for their habitation. The folly and wickedness of mankind, and necessities proceeding from these

causes, have driven multitudes of the species to seek a refuge among burning sands, while countries blessed with hospitable skies and with the most fertile soils remain almost without a human tenant. We invade the territories of wild beasts and venomous reptiles, and then complain that we are infested by their bites and stings.[78] Some accounts of Africa place this observation in a strong point of view. "The deserts," says Adamson, "are entirely barren, except where they are found to produce serpents, and in such quantities that some extensive plains are almost entirely covered with them." These are the natures appropriated to the situation. Let them enjoy their existence; let them have their country. Surface enough will be left to man, though his numbers were increased a hundred fold, and left to him where he might live exempt from these annoyances.

The SECOND CASE, *viz.*, that of animals *devouring* one another, furnishes a consideration of much larger extent. To judge whether, as a general provision, this can be deemed an *evil*, even so far as we understand its consequences, which, probably, is a partial understanding, the following reflections are fit to be attended to.[79]

[78] This argument seems to prove too much, since it would conclude against the extension of civilization. This can hardly take place without "invading the territories of wild beasts and venomous reptiles."—*Am. Ed.*

[79] In regard to apparently conflicting contrivances, including conflicting instincts, as well as apparently imperfect contrivances and instinct, it should be observed, that the progress of science is constantly diminishing the number of such instances, as far as our ignorance of design goes. That some conflict will continue; in other words, that evil to a certain amount will, after all deductions, be found to exist, cannot be doubted. But that an immense preponderance of good exists in every department of nature, both of matter and of mind, is so clear that, arguing as we do on every other subject, we have a right to impute the perception of any evil at all to our own ignorance; and to conclude that, if we knew the whole system, and could extend our comprehension to the entire plan of creation, we should no longer believe there was evil at all. Of the different hypotheses to which we may have recourse for explaining what we are unable legitimately to solve, the probationary state is one, and is the one which appears to tally best

1. Immortality upon this earth is out of the question. Without death there could be no generation, no sexes, no parental relation, *i. e.*, as things are constituted, no animal happiness. The particular duration of life assigned to different animals can form no part of the objection; because, whatever that duration be, while it remains finite and limited, it may always be asked why it is no longer. The natural age of different animals varies from a single day to a century of years. No account can be given of this; nor could any be given, whatever other proportion of life had obtained among them.

The term, then, of life in different animals being the same as it is, the question is, what mode of taking it away is the best, even for the animal itself.

Now, according to the established order of nature (which we must suppose to prevail, or we cannot reason at all upon the subject), the three methods by which life is usually put an end to are acute diseases, decay, and violence. The simple and natural life of *brutes* is not often visited by acute distempers; nor could it be deemed an improvement of their lot if they were. Let it be considered, therefore, in what a condition of suffering and misery a brute animal is placed which is left to perish by *decay*. In human sickness or infirmity, there is the assistance of man's rational fellow-creatures, if not to alleviate his pains, at least to minister to his necessities, and to supply the place of his own activity. A brute, in his wild and natural state, does everything for himself. When his strength, therefore, or his speed, or his limbs, or his senses fail him, he is delivered over either to absolute famine, or to the protracted wretchedness of a life slowly wasted by the scarcity of food. Is it, then, to see the world filled with drooping, superannuated, half-starved, helpless, and unhelp-

with the facts. It is hardly necessary to add that we are now, as throughout these notes, after the example of the author, confining ourselves altogether to the intimations received from natural reason and observation, unaided by the light of revelation.

ed animals, that you would alter the present system of pursuit and prey?[80]

2. Which system is also to them the spring of motion and activity on both sides. The pursuit of its prey forms the employment, and appears to constitute the pleasure, of a considerable part of the animal creation. The using of the means of defence, or flight, or precaution, forms also the business of another part. And even of this latter tribe we have no reason to suppose that their happiness is much molested by their fears. Their danger exists continually; and in some cases they seem to be so far sensible of it as to provide, in the best manner they can, against it; but it is only when the attack is actually made upon them that they appear to suffer from it. To contemplate the insecurity of their condition with anxiety and dread, requires a degree of reflection which (happily for themselves) they do not possess. A *hare*, notwithstanding the number of its dangers and its enemies, is as playful an animal as any other.

3. But, to do justice to the question, the system of animal *destruction* ought always to be considered in strict connexion with another property of animal nature, viz., *superfecundity*. They are countervailing qualities. One subsists by the correction of the other. In treating, therefore, of the subject under this view (which is, I believe, the true one), our business will be, first, to point out the advantages which are gained by the powers in nature of a superabundant multiplication; and then to show that these advantages are so many reasons for appointing that system of national hostilities which we are endeavouring to account for.

In almost all cases nature produces her supplies with profusion. A single codfish spawns, in one season, a greater number of eggs than all the inhabitants

[80] This argument would appear more conclusive if it could be shown that animals do not usually fall a prey to their natural enemies till the period for their decay has arrived.—*Am. Ed.*

of England amount to. A thousand other instances of prolific generation might be stated, which, though not equal to this, would carry on the increase of the species with a rapidity which outruns calculation, and to an immeasurable extent. The advantages of such a constitution are two; first, that it tends to keep the world always full; while, secondly, it allows the proportion between the several species of animals to be differently modified, as different purposes require, or as different situations may afford for them room and food. Where this vast fecundity meets with a vacancy fitted to receive the species, there it operates with its whole effect; there it pours in its numbers and replenishes the waste. We complain of what we call the exorbitant multiplication of some troublesome insects; not reflecting that large portions of nature might be left void without it. If the accounts of travellers may be depended upon, immense tracts of forests in North America would be nearly lost to sensitive existence if it were not for *gnats*. "In the thinly inhabited regions of America, in which the waters stagnate and the climate is warm, the whole air is filled with crowds of insects." Thus it is, that where we looked for solitude and deathlike silence, we meet with animation, activity, enjoyment; with a busy, a happy, and a peopled world. Again; hosts of *mice* are reckoned among the plagues of the northeast part of Europe; whereas vast plains in Siberia, as we learn from good authority, would be lifeless without them. The Caspian deserts are converted by their presence into crowds of warrens. Between the Volga and the Yaik, and in the country of Hyrcania, the ground, says Pallas, is in many places *covered* with little hills, raised by the earth cast out in forming the burrows. Do we so envy these blissful abodes as to pronounce the fecundity by which they are supplied with inhabitants to be an evil; a subject of complaint, and not of praise? Farther, by virtue of this same superfecundity, what we term destruction becomes almost instantly the parent of life. What we call blights are

oftentimes legions of animated beings, claiming their portion in the bounty of nature. What corrupts the produce of the earth to us prepares it for them. And it is by means of their rapid multiplication that they take possession of their pasture; a slow propagation would not meet the opportunity.

But, in conjunction with the occasional use of this fruitfulness, we observe, also, that it allows the proportion between the several species of animals to be differently modified, as different purposes of utility may require. When the forests of America come to be cleared and the swamps drained, our gnats will give place to other inhabitants. If the population of Europe should spread to the north and the east, the mice will retire before the husbandman and the shepherd, and yield their station to herds and flocks. In what concerns the human species, it may be a part of the scheme of Providence that the earth should be inhabited by a shifting, or, perhaps, a circulating population. In this economy it is possible that there may be the following advantages: When old countries are become exceedingly corrupt, simpler modes of life, purer morals, and better institutions may rise up in new ones, while fresh soils reward the cultivator with more plentiful returns. Thus the different portions of the globe come into use in succession as the residence of man, and, in his absence, entertain other guests which, by their multiplication, fill the chasm. In domesticated animals we find the effect of their fecundity to be, that we can always command *numbers*; we can always have as many of any particular species as we please or as we can support. Nor do we complain of its excess; it being much more easy to regulate abundance than to supply scarcity.

But, then, this *superfecundity*, though of great occasional use and importance, exceeds the ordinary capacity of nature to receive or support its progeny. All superabundance supposes destruction, or must destroy itself. Perhaps there is no species of terrestrial animals whatever which would not overrun the earth if it were permitted to multiply in perfect safe

ty;[81] or of fish, which would not fill the ocean; at least, if any single species were left to their natural increase without disturbance or restraint, the food of other species would be exhausted by their maintenance. It is necessary, therefore, that the effects of such prolific faculties be curtailed. In conjunction with other checks and limits, all subservient to the same purpose, are the *thinnings* which take place among animals by their action upon one another. In some instances we ourselves experience, very directly, the use of these hostilities. One species of insects rids us of another species, or reduces their ranks. A third species, perhaps, keeps the second within bounds; and birds or lizards are a fence against the ordinate increase by which even these last might infest us. In other more numerous, and, possibly, more important instances, this disposition of things, although less necessary or useful to us, and, of course, less observed by us, may be necessary and useful to certain other species; or even for the preventing of the loss of certain species from the universe: a misfortune which seems to be studiously guarded against. Though there may be the appearance of failure in some of the details of Nature's works, in her great purposes there never are. Her species never fail. The provision which was originally made for contin-

[81] This passage, taken in connexion with one which will be noticed on a following page, seems to show that, in the author's estimation, *superfecundity* is a property of the human race as well as of inferior animals. If so, his reflections in regard to the uses of hostility and mutual destruction among animals might be extended to wars among nations; and we might plead for war as one of the Creator's provisions to guard against excess of population. This application of the argument may induce some doubt, whether the author's reasoning on this question will bear all the stress which he lays upon it. The truth is, that on many of these subjects we are profoundly ignorant; and, in dealing with the great problem of Evil, it is surely safer to acknowledge our ignorance than to rest the vindication of God's goodness on considerations of so doubtful a nature. He has vouchsafed so many and such incontestable evidences of his benevolence, that we can well afford to trust Him, though he should sometimes veil his purposes in darkness.—*Am. Ed.*

uing the replenishment of the world, has proved itself to be effectual through a long succession of ages.

What farther shows that the system of destruction among animals holds an express relation to the system of fecundity—that they are parts, indeed, of one compensatory scheme—is, that in each species the fecundity bears a proportion to the smallness[82] of the animal, to the weakness, to the shortness of its natural term of life, and to the dangers and enemies by which it is surrounded. An elephant produces but one calf; a butterfly lays six hundred eggs. Birds of prey seldom produce more than two eggs; the sparrow tribe and the duck tribe frequently sit upon a dozen. In the rivers we meet with a thousand minnows for one pike; in the sea a million of herrings for a single shark. Compensation obtains throughout. Defencelessness and devastation are repaired by fecundity.

We have dwelt the longer on these considerations, because the subject to which they apply, namely, that of animals *devouring* one another, forms the chief, if not the only instance, in the works of the Deity, of an economy stamped by marks of design, in which the character of utility can be called in question. The case of *venomous* animals is of much inferior consequence to the case of prey, and, in some degree, is also included under it. To both cases it is probable that many more reasons belong than those of which we are in possession.

Our FIRST PROPOSITION, and that which we have hitherto been defending, was, "that, in a vast plurality of instances, in which *contrivance* is perceived, the design of the contrivance is beneficial."

Our SECOND PROPOSITION is, "that the Deity has added *pleasure* to animal sensations beyond what was necessary for any other purpose, or when the purpose, so far as it was necessary, might have been effected by the operation of pain."[83]

[82] This is not strictly correct; the codfish, for example, being more prolific, according to the author's own showing on a previous page, than almost any other animal, even the smallest.—*Am. Ed.*

[83] This is a most important consideration, and one which can-

This proposition may be thus explained: The capacities which, according to the established course of nature, are *necessary* to the support or preservation of an animal, however manifestly they may be the result of an organization contrived for the purpose, can only be deemed an act or a part of the same will as that which decreed the existence of the animal itself; because, whether the creation proceeded from a benevolent or a malevolent being, these capacities must have been given if the animal existed at all. Animal properties, therefore, which fall under this description, do not strictly prove the goodness of God; they may prove the existence of the Deity; they may prove a high degree of power and intelligence, but they do not prove his goodness; forasmuch as they must have been found in any creation which was capable of continuance, although it is possible to suppose that such a creation might have been produced by a being whose views rested upon misery.

But there is a class of properties which may be said to be superadded from an intention expressly directed to happiness; an intention to give a happy ex-

not be dwelt upon too constantly; and which assuredly will, by the contemplative and well-regulated mind, never be dwelt upon without experiencing the most pleasing and salutary influence. It will be farther illustrated in the Appendix; but in this place it may be right to add, that the induction of facts plainly shows the system of the universe to be governed upon the principle of inducement rather than denouncement; of reward more than of punishment; and not only are sentient beings guided by the more kindly process where the harsher would have sufficed, but there is more inducement employed, more pleasure superadded, than is even necessary to work the effect intended. It is as if a human lawgiver were to prefer rewarding his subjects for obedience rather than punishing them for contumacy; and were then to add some bounty beyond what had been found quite sufficient to ensure their compliance. It must be constantly borne in mind, that there is not one single act performed by any animal, from man to the lowest insect in the scale, in fulfilling the apparent ends of its creation, the performance of which might not have been secured as effectually by the pressure or by the apprehension of pain, as it now is, in so vast a number of instances, solicited by the enjoyment or the hope of some gratification.

istence distinct from the general intention of providing the means of existence; and that is, of capacities for pleasure, in cases wherein, so far as the conservation of the individual or of the species is concerned, they were not wanted, or wherein the purpose might have been secured by the operation of pain. The provision which is made of a variety of objects, not necessary to life, and ministering only to our pleasures, and the properties given to the necessaries of life themselves, by which they contribute to pleasure as well as preservation, show a farther design than that of giving existence.*

A single instance will make all this clear. Assuming the necessity of food for the support of animal life, it is requisite that the animal be provided with organs fitted for the procuring, receiving, and digesting of its food. It may also be necessary, that the animal be impelled by its sensations to exert its organs. But the pain of hunger would do all this. Why add pleasure to the act of eating; sweetness and relish to food? why a new and appropriate sense for the perception of the pleasure? Why should the juice of a peach, applied to the palate, affect the part so differently from what it does when rubbed upon the palm of the hand? This is a constitution which, so far as appears to me, can be resolved into nothing but the pure benevolence of the Creator. Eating is necessary, but the pleasure attending it is not necessary: and that its pleasure depends, not only upon our being in possession of the sense of taste, which is different from every other, but upon a particular state of the organ in which it resides, a felicitous adaptation of the organ to the object, will be confessed by any one who may happen to have experienced that vitiation of taste which frequently occurs in fevers, when every taste is irregular, and every one bad.

* See this topic considered in Dr. Balguy's Treatise upon the Divine Benevolence. This excellent author first, I think, proposed it, and nearly in the terms in which it is here stated. Some other observations also under this head are taken from that treatise.—*Note of the Author.*

In mentioning the gratifications of the palate, it may be said that we have made choice of a trifling example.[84] I am not of that opinion. They afford a share of enjoyment to man, but to brutes I believe that they are of a very great importance. A horse at liberty passes a great part of his waking hours in eating. To the ox, the sheep, the deer, and other ruminating animals, the pleasure is doubled. Their whole time almost is divided between browsing upon their pasture and chewing their cud. Whatever the pleasure be, it is spread over a large portion of their existence. If there be animals, such as the lupous-fish, which swallow their prey whole and at once,

[84] Neither this nor any other thing which our nature, physical or moral, is formed to relish, can be deemed trifling; and it is well observed afterward that the very capacity of being pleased with what, by comparison with other things, are termed trivial matters, is itself a source of enjoyment provided for us by the Divine beneficence. All men have within themselves the power of being amused, or occupied and interested—that is, pleased, gratified—with things which, until they make the attempt, they are disposed to regard as wholly incapable of affording any satisfaction. This is a most important source of enjoyment, and one more independent of external circumstances than they could believe who have never made the experiment. "Le goût (says Marmontel, *Mém.* i., 431), s'accommode aux objects dont il peut jouir; et cette sage maxime,

> Quand on n'a pas ce que l'on aime,
> Il faut aimer ce que l'on a,

est en effet non seulement une leçon de la nature, mais un moyen qu'elle se ménage pour nous procurer des plaisirs." The earlier and by far the most interesting part of his book abounds in illustrations of a kindred truth, the gratification derived from the humblest sources by those who have known none other. "Nos galettes de sarrazin, humectées, toutes brûlantes, de ce bon beurre du Mont-d'or, étaient pour nos le plus friand régal. Je ne sais pas quel mets nous eût paru meilleur que nos raves et nos châtaignes; et en hiver, lorsque ces belles raves grillaient le soir à l'entour du foyer, ou que nous entendions bouillonner l'eau du vase où cuisaient ces châtaignes si savoureuses et si douces, le cœur nous palpitait de joie."—(Ib., p. 9.) "Quand j'arrivais chez moi, et que, dans un bon lit ou au coin d'un bon feu, je me sentais tout ranimé, c'était pour moi l'un des moments les plus délicieux de la vie; jouissance que la mollesse ne m'aurait jamais fait connaître."—(Ib., 34.)

without any time, as it should seem, for either drawing out or relishing the taste in the mouth, is it an improbable conjecture that the seat of taste with them is in the stomach; or, at least, that a sense of pleasure, whether it be taste or not, accompanies the dissolution of the food in that receptacle, which dissolution in general is carried on very slowly? If this opinion be right, they are more than repaid for the defect of palate. The feast lasts as long as the digestion.

In seeking for argument, we need not stay to insist upon the comparative importance of our example: for the observation holds equally of all, or of three at least, of the other senses. The necessary purposes of hearing might have been answered without harmony; of smell without fragrance; of vision without beauty. Now "if the Deity had been indifferent about our happiness or misery, we must impute to our good fortune (as all design by this supposition is excluded) both the capacity of our senses to receive pleasure, and the supply of external objects fitted to excite it." I allege these as *two* felicities, for they are different things, yet both necessary: the sense being formed, the objects which were applied to it might not have suited it; the objects being fixed, the sense might not have agreed with them. A coincidence is here required which no accident can account for. There are three possible suppositions upon the subject, and no more. The first, that the sense, by its original constitution, was made to suit the object: the second, that the object, by its original constitution, was made to suit the sense: the third, that the sense is so constituted as to be able, either universally or within certain limits, by habit and familiarity, to render every object pleasant. Whichever of these suppositions we adopt, the effect evinces, on the part of the author of nature, a studious benevolence. If the pleasures which we derive from any of our senses depend upon an original congruity between the sense and the properties perceived by it, we know by experience that the ad-

justment demanded, with respect to the qualities which we conferred upon the objects that surround us, not only choice and selection, out of a boundless variety of possible qualities with which these objects might have been endued, but a *proportioning also of degree*, because an excess or defect of intensity spoils the perception, as much almost as an error in the kind and nature of the quality. Likewise the degree of dulness or acuteness in the sense itself is no arbitrary thing; but, in order to preserve the congruity here spoken of, requires to be in an exact or near correspondence with the strength of the impression. The dulness of the senses forms the complaint of old age. Persons in fevers, and, I believe, in most maniacal cases, experience great torment from their preternatural acuteness. An increased, no less than an impaired sensibility, induces a state of disease and suffering.

The doctrine of a specific congruity between animal senses and their objects is strongly favoured by what is observed of insects in the election of their food. Some of these will feed upon one kind of plant or animal, and upon no other; some caterpillars upon the cabbage alone; some upon the black currant alone. The species of caterpillar which eats the vine will starve upon the alder; nor will that which we find upon fennel touch the rosebush. Some insects confine themselves to two or three kinds of plants or animals. Some, again, show so strong a preference as to afford reason to believe that, though they may be driven by hunger to others, they are led by the pleasure of taste to a few particular plants alone; and all this, as it should seem, independently of habit or imitation.

But should we accept the third hypothesis, and even carry it so far as to ascribe everything which concerns the question to habit (as in certain species, the human species most particularly, there is reason to attribute something), we have then before us an animal capacity, not less, perhaps, to be admired than the native congruities which the other scheme adopts. It

cannot be shown to result from any fixed necessity in nature, that what is frequently applied to the senses should of course become agreeable to them. It is, so far as it subsists, a power of accommodation provided in these senses by the author of their structure, and forms a part of their perfection.

In whichever way we regard the senses, they appear to be specific gifts, ministering not only to preservation, but to pleasure. But what we usually call the *senses*, are probably themselves far from being the only vehicles of enjoyment, or the whole of our constitution which is calculated for the same purpose. We have many internal sensations of the most agreeable kind, hardly referable to any of the five senses. Some physiologists have holden that all secretion is pleasurable; and that the complacency which in health, without any external assignable object to excite it, we derive from life itself, is the effect of our secretions going on well within us. All this may be true; but, if true, what reason can be assigned for it, except the will of the Creator? It may reasonably be asked, Why is anything a pleasure? and I know no answer which can be returned to the question but that which refers it to appointment.

We can give no account whatever of our pleasures in the simple and original perception; and, even when physical sensations are assumed, we can seldom account for them in the secondary and complicated shapes in which they take the name of diversions. I never yet met a sportsman who could tell me in what the sports consisted; who could resolve it into its principle, and state that principle. I have been a great follower of fishing myself, and in its cheerful solitude have passed some of the happiest hours of a sufficiently happy life: but to this moment I could never trace out the source of the pleasure which it afforded me.

The "quantum in rebus inane!" whether applied to our amusements or to our graver pursuits (to which, in truth, it sometimes equally belongs), is always an unjust complaint. If trifles engage, and if trifles

make us happy, the true reflection suggested by the experiment is upon the tendency of nature to gratification and enjoyment; which is, in other words, the goodness of its Author towards his sensitive creation.

Rational natures also, as such, exhibit qualities which help to confirm the truth of our position. The degree of understanding found in mankind is usually much greater than what is necessary for mere preservation. The pleasure of choosing for themselves, and of prosecuting the object of their choice, should seem to be an original source of enjoyment. The pleasures received from things great, beautiful, or new, from imitation, or from the liberal arts, are in some meas ure not only superadded, but unmixed gratifications, having no pains to balance them.*

I do not know whether our attachment to *property* be not something more than the mere dictate of reason, or even than the mere effect of association. Property communicates a charm to whatever is the object of it. It is the first of our abstract ideas; it cleaves to us the closest and the longest. It endears to the child its plaything, to the peasant his cottage, to the landholder his estate. It supplies the place of prospect and scenery. Instead of coveting the beauty of distant situations, it teaches every man to find it in his own. It gives boldness and grandeur to plains and fens, tinge and colouring to clays and fallows.

All these considerations come in aid of our *second* proposition. The reader will now bear in mind what our two propositions were. They were, first, that in a vast plurality of instances in which contrivance is perceived, the design of the contrivance is beneficial: secondly, that the Deity has added pleasure to animal sensations beyond what was necessary for any other purpose; or when the purpose, so far as it was necessary, might have been effected by the operation of pain.

While these propositions can be maintained, we are authorized to ascribe to the Deity the character of benevolence; and what is benevolence at all must in

* Balguy on the Divine Benevolence.

him be *infinite* benevolence, by reason of the infinite, that is to say, the incalculably great number of objects upon which it is exercised.

Of the ORIGIN OF EVIL no universal solution has been discovered; I mean, no solution which reaches to all cases of complaint. The most comprehensive is that which arises from the consideration of *general rules*.[85] We may, I think, without much difficulty, be brought to admit the four following points: first, that important advantages may accrue to the universe from the order of nature proceeding according to general laws: secondly, that general laws, however well set and constituted, often thwart and cross one another: thirdly, that from these thwartings and crossings frequent particular inconveniences will arise: and, fourthly, that it agrees with our observation to suppose that some degree of these inconveniences takes place in the works of nature. These points may be allowed; and it may also be asserted, that the general laws with which we are acquainted are directed to beneficial ends. On the other hand, with many of these laws we are not acquainted at all, or we are totally unable to trace them in their branches and their operation; the effect of which ignorance is, that they cannot be of importance to us as measures by which to regulate our conduct. The conservation of them may be of importance in other respects or to other

[85] These observations on General Laws, and those which follow upon the doctrine of Imperfections, have been misunderstood, in the same way with the former remarks referred to in the second note upon this chapter; but it must be allowed that the expressions here used respecting General Laws are somewhat incautious, and more liable to cavil. Nevertheless, the whole scope of the argument which follows plainly shows that our author never thought of solving the difficulty as to evil by resorting to the existence of laws which are themselves only the modes of acting pursued by the Deity himself. In truth, this portion of his argument is, like that on which we formerly commented, only to be considered as stating a deduction to be made from the total amount of evil; in other words, the reasoning is only a reduction of the apparent quantity to the real. Anything beyond this would really be recurring to the ancient doctrine of the heathens, whose gods were limited in power and controlled by fate.

beings, but we are uninformed of their value or use; uninformed, consequently, when and how far they may or may not be suspended, or their effects turned aside by a presiding or benevolent will, without incurring greater evils than those which would be avoided. The consideration, therefore, of general laws, although it may concern the question of the origin of evil, very nearly (which I think it does), rests in views disproportionate to our faculties, and in a knowledge which we do not possess. It serves rather to account for the obscurity of the subject than to supply us with distinct answers to our difficulties. However, while we assent to the above-stated propositions as principles, whatever uncertainty we may find in the application, we lay a ground for believing that cases of apparent evil, for which *we* can suggest no particular reason, are governed by reasons which are more general, which lie deeper in the order of second causes, and which, on that account, are removed to a greater distance from us.

The doctrine of *imperfections*, or, as it is called, of evils of imperfection, furnishes an account founded, like the former, in views of universal nature. The doctrine is briefly this: It is probable that creation may be better replenished by sensitive beings of different sorts, than by sensitive beings all of one sort. It is likewise probable that it may be better replenished by different orders of beings, rising one above another in gradation, than by beings possessed of equal degrees of perfection. Now a gradation of such beings implies a gradation of imperfections. No class can justly complain of the imperfections which belong to its place in the scale, unless it were allowable for it to complain that a scale of being was appointed in nature; for which appointment there appear to be reasons of wisdom and goodness.

In like manner, *finiteness*, or what is resolvable into finiteness, in inanimate subjects, can never be a just subject of complaint; because, if it were ever so, it would be always so; we mean, that we can never reasonably demand that things should be larger or

more, when the same demand might be made, whatever the quantity or number was.

And to me it seems that the sense of mankind has so far acquiesced in these reasons, as that we seldom complain of evils of this class when we clearly perceive them to be such. What I have to add, therefore, is, that we ought not to complain of some other evils which stand upon the same foot of vindication as evils of confessed imperfection. We never complain that the globe of our earth is too small: nor should we complain, if it were even much smaller. But where is the difference to us between a less globe, and part of the present being uninhabitable? The inhabitants of an island may be apt enough to murmur at the sterility of some parts of it, against its rocks, or sands, or swamps: but no one thinks himself authorized to murmur simply because the island is not larger than it is. Yet these are the same griefs.

The above are the two metaphysical answers which have been given to this great question. They are not the worse for being metaphysical, provided they be founded (which I think they are) in right reasoning: but they are of a nature too wide to be brought under our survey, and it is often difficult to apply them in the detail. Our speculations, therefore, are better employed when they confine themselves within a narrower circle.

The observations which follow are of this more limited, but more determinate kind.

Of *bodily pain*, the principal observation, no doubt, is that which we have already made and dwelt upon, *viz.*, "that it is seldom the object of contrivance; that, when it is so, the contrivance rests ultimately in good."

To which, however, may be added, that the annexing of pain to the means of destruction is a salutary provision, inasmuch as it teaches vigilance and caution; both gives notice of danger, and excites those endeavours which may be necessary to preservation. The evil consequence which sometimes arises from

the want of that timely intimation of danger which pain gives, is known to the inhabitants of cold countries by the example of frostbitten limbs. I have conversed with patients who had lost toes and fingers by this cause. They have in general told me that they were totally unconscious of any local uneasiness at the time. Some I have heard declare that, while they were about their employment, neither their situation nor the state of the air was unpleasant. They felt no pain; they suspected no mischief; till, by the application of warmth, they discovered, too late, the fatal injury which some of their extremities had suffered. I say that this shows the use of pain, and that we stand in need of such a monitor. I believe, also, that the use extends farther than we suppose or can now trace; that to disagreeable sensations we, and all animals, owe, or have owed, many habits of action which are salutary, but which are become so familiar as not easily to be referred to their origin.

[86] Pain also itself is not without its *alleviations*. It may be violent and frequent; but it is seldom both violent and long-continued: and its pauses and intermissions become positive pleasures. It has the power of shedding a satisfaction over intervals of ease, which, I believe, few enjoyments exceed. A man resting from a fit of the stone or gout is, for the time, in possession of feelings which undisturbed health cannot impart. They may be dearly bought, but still they are to be set against the price. And, indeed, it depends upon the duration and urgency of the pain whether they be dearly bought or not. I am far from being sure that a man is not a gainer by suffering a moderate interruption of bodily ease for a couple of

[86] This chapter, we are told by Dr. Fenwick, in his sketch of Dr. Clark's life, "was written when Dr. Paley was suffering under severe attacks of a painful disorder under which he had long laboured, and which afterward proved fatal." Dr. Fenwick justly remarks upon the additional interest which this circumstance communicates to the author's remarks upon the interruptions of pain.—Meadly's Memoirs of Paley, p. 204.

hours out of the four-and-twenty. Two very common observations favour this opinion: one is, that remissions of pain call forth, from those who experience them, stronger expressions of satisfaction and of gratitude towards both the author and the instruments of their relief, than are excited by advantages of any other kind: the second is, that the spirits of sick men do not sink in proportion to the acuteness of their sufferings, but rather appear to be roused and supported, not by pain, but by the high degree of comfort which they derive from its cessation, or even its subsidence, whenever that occurs; and which they taste with a relish that diffuses some portion of mental complacency over the whole of that mixed state of sensations in which disease has placed them.

In connexion with bodily pain may be considered bodily *disease*, whether painful or not. Few diseases are fatal. I have before me the account of a dispensary in the neighbourhood, which states six years' experience as follows:

Admitted	6429;
Cured	5576;
Dead	234;

and this I suppose nearly to agree with what other similar institutions exhibit. Now in all these cases some disorder must have been felt, or the patients would not have applied for a remedy; yet we see how large a proportion of the maladies which were brought forward have either yielded to proper treatment, or, what is more probable, ceased of their own accord. We owe these frequent recoveries, and, where recovery does not take place, this patience of the human constitution under many of the distempers by which it is visited, to two benefactions of our nature. One is, that she works within certain limits, allows of a certain latitude, within which health may be preserved, and in the confines of which it only suffers a graduated diminution. Different quantities of food, different degrees of exercise, different portions of sleep, different states of the atmosphere, are compatible with the possession of health. So like-

wise it is with the secretions and excretions, with many internal functions of the body, and with the state, probably, of most of its internal organs. They may vary considerably, not only without destroying life, but without occasioning any high degree of inconvenience. The other property of our nature, to which we are still more beholden, is its constant endeavour to restore itself, when disordered, to its regular course. The fluids of the body appear to possess a power of separating and expelling the noxious substance which may have mixed itself with them. This they do, in eruptive fevers, by a kind of despumation, as Sydenham calls it, analogous in some measure to the intestine action by which fermenting liquors work the yest to the surface. The solids, on their part, when their action is obstructed, not only resume that action as soon as the obstruction is removed, but they struggle with the impediment. They take an action as near to the true one as the difficulty and the disorganization with which they have to contend will allow of.

Of *mortal* diseases, the great use is to reconcile us to death. The horror of death proves the value of life. But it is in the power of disease to abate, or even extinguish this horror, which it does in a wonderful manner, and oftentimes by a mild and imperceptible gradation. Every man who has been placed in a situation to observe it, is surprised at the change which has been wrought in himself when he compares the view which he entertains of death upon a sick bed with the heart-sinking dismay with which he should some time ago have met it in health. There is no similitude between the sensations of a man led to execution, and the calm expiring of a patient at the close of his disease. Death to him is only the last of a long train of changes, in his progress through which it is possible that he may experience no shocks or sudden transitions.

Death itself, as a mode of removal and of succession, is so connected with the whole order of our animal world, that almost everything in that world must

be changed to be able to do without it. It may seem likewise impossible to separate the fear of death from the enjoyment of life, or the perception of that fear from rational natures. Brutes are in a great measure delivered from all anxiety on this account by the inferiority of their faculties, or, rather, they seem to be armed with the apprehension of death just sufficiently to put them upon the means of preservation, and no farther. But would a human being wish to purchase this immunity at the expense of those mental powers which enable him to look forward to the future?

Death implies *separation:* and the loss of those whom we love must necessarily, so far as we can conceive, be accompanied with pain. To the brute creation nature seems to have stepped in with some secret provision for their relief under the rupture of their attachments. In their instincts towards their offspring, and of their offspring to them, I have often been surprised to observe how ardently they love and how soon they forget. The pertinacity of human sorrow (upon which time also, at length, lays its softening hand) is probably, therefore, in some manner connected with the qualities of our rational or moral nature. One thing, however, is clear, *viz.*, that it is better that we should possess affections, the sources of so many virtues and so many joys, although they be exposed to the incidents of life as well as the interruptions of mortality, than, by the want of them, be reduced to a state of selfishness, apathy, and quietism.[87]

Of other external evils (still confining ourselves to what are called physical or natural evils) a considerable part come within the scope of the following observation: The great principle of human satisfaction is *engagement.* It is a most just distinction, which the late Mr. Tucker has dwelt upon so largely in his works, between pleasures in which we are passive and pleasures in which we are active. And, I be-

[87] The remarks made in the two former notes (77 and 85) are applicable to this part of the text also.

lieve, every attentive observer of human life will assent to his position, that, however grateful the sensations may occasionally be in which we are passive, it is not these, but the latter class of our pleasures, which constitute satisfaction, which supply that regular stream of moderate and miscellaneous enjoyments in which happiness, as distinguished from voluptuousness, consists. Now for rational occupation, which is, in other words, for the very material of contented existence, there would be no place left if either the things with which we had to do were absolutely impracticable to our endeavours, or if they were too obedient to our uses. A world, furnished with advantages on one side, and beset with difficulties, wants, and inconveniences on the other, is the proper abode of free, rational, and active natures, being the fittest to stimulate and exercise their faculties. The very *refractoriness* of the objects they have to deal with contributes to this purpose. A world in which nothing depended upon ourselves, however it might have suited an imaginary race of beings, would not have suited mankind. Their skill, prudence, industry; their various arts, and their best attainments, from the application of which they draw, if not their highest, their most permanent gratifications, would be insignificant if things could be either moulded by our volitions, or, of their own accord, conformed themselves to our views and wishes. Now it is in this refractoriness that we discern the seed and principle of *physical* evil, as far as it arises from that which is external to us.

Civil evils,[88] or the evils of civil life, are much more easily disposed of than physical evils: because they

[88] In all arguments respecting civil and political evils, it is important to keep the distinction steadily in view between contentment under necessary sufferings, and quietism under such as may be avoided by improvements in our institutions. Contentment, indeed, under even the latter, is a virtue as well as a solace, during the period required for their safe and legitimate amendment; but this is no exception to the rule which we have glanced at; for the sufferings must be considered necessary until their removal can be safely effected.

are, in truth, of much less magnitude, and also because they result, by a kind of necessity, not only from the constitution of our nature, but from a part of that constitution which no one would wish to see altered. The case is this: Mankind will in every country *breed up* to a certain point of distress. That point may be different in different countries or ages, according to the established usages of life in each. It will also shift upon the scale, so as to admit of a greater or less number of inhabitants, according as the quantity of provision, which is either produced in the country or supplied to it from other countries, may happen to vary. But there must always be such a point, and the species will always breed up to it. The order of generation proceeds by something like a geometrical progression. The increase of provision, under circumstances even the most advantageous, can only assume the form of an arithmetic series. Whence it follows that the population will always overtake the provision, will pass beyond the line of plenty, and will continue to increase till checked by the difficulty of procuring subsistence.* Such difficulty, therefore, along with its attendant circumstances, *must* be found in every old country; and these circumstances constitute what we call poverty, which necessarily imposes labour, servitude, restraint.[89]

It seems impossible to people a country with inhabitants who shall be all easy in circumstances. For, suppose the thing to be done, there would be such

* See a statement of this subject in a late treatise upon population.—*Note of the Author.*

[89] That evil ought never to be charged on "the constitution of nature" which can be shown to spring from the misconduct of man. Of this nature is much, if not all, of the difficulty of procuring subsistence which is often experienced in older countries. Instead of ascribing this to the superfecundity of the species, it would seem more reasonable to look for its cause in the improvidence, idleness, and vice which are so prevalent in such countries, as well as in the deficient culture of the people, and the unwise policy of the government. The treatise on population referred to by the author in his note was doubtless that of the late Mr. Malthus; an able and ingenious writer, but one whose speculations are not to be received implicitly.—*Am. Ed.*

marrying and giving in marriage among them as would in a few years change the face of affairs entirely: *i. e.*, as would increase the consumption of those articles which supplied the natural or habitual wants of the country to such a degree of scarcity as must leave the greatest part of the inhabitants unable to procure them without toilsome endeavours; or, out of the different kinds of these articles, to procure any kind except that which was most easily produced. And this, in fact, describes the condition of the mass of the community in all countries: a condition unavoidably, as it should seem, resulting from the provision which is made in the human, in common with all animal constitutions, for the perpetuity and multiplication of the species.

It need not, however, dishearten any endeavours for the public service to know that population naturally treads upon the heels of improvement. If the condition of a people be meliorated, the consequence will be, either that the *mean* happiness will be increased, or a greater number partake of it; or, which is most likely to happen, that both effects will take place together. There may be limits fixed by nature to both, but they are limits not yet attained, nor even approached, in any country of the world.

And when we speak of limits at all, we have respect only to provisions for animal wants. There are sources, and means, and auxiliaries, and augmentations of human happiness, communicable without restriction of numbers; as capable of being possessed by a thousand persons as by one. Such are those which flow from a mild contrasted with a tyrannic government, whether civil or domestic; those which spring from religion; those which grow out of a sense of security; those which depend upon habits of virtue, sobriety, moderation, order: those, lastly, which are found in the possession of well-directed tastes and desires, compared with the dominion of tormenting, pernicious, contradictory, unsatisfied, and unsatisfiable passions.

The *distinctions* of civil life are apt enough to be

regarded as evils by those who sit under them; but, in my opinion, with very little reason.

In the first place, the advantages which the higher conditions of life are supposed to confer, bear no proportion in value to the advantages which are bestowed by nature. The gifts of nature always surpass the gifts of fortune. How much, for example, is activity better than attendance; beauty than dress; appetite, digestion, and tranquil bowels, than all the studies of cookery, or than the most costly compilation of forced or far-fetched dainties!

Nature has a strong tendency to equalization. Habit, the instrument of nature, is a great leveller; the familiarity which it induces taking off the edge both of our pleasures and our sufferings. Indulgences which are habitual keep us in ease, and cannot be carried much farther. So that, with respect to the gratifications of which the senses are capable, the difference is by no means proportionable to the apparatus. Nay, so far as superfluity generates fastidiousness, the difference is on the wrong side.

It is not necessary to contend, that the advantages derived from wealth are none (under due regulations they are certainly considerable), but that they are not greater than they ought to be. *Money* is the sweetener of human toil; the substitute for coercion; the reconciler of labour with liberty. It is, moreover, the stimulant of enterprise in all objects and undertakings, as well as of diligence in the most beneficial arts and employments. Now, did affluence, when possessed, contribute nothing to happiness, or nothing beyond the mere supply of necessaries, and the secret should come to be discovered, we might be in danger of losing great part of the uses which are at present derived to us through this important medium. Not only would the tranquillity of social life be put in peril by the want of a motive to attach men to their private concerns, but the satisfaction which all men receive from success in their respective occupations, which collectively constitutes the great mass of hu-

man comfort, would be done away in its very principle.

With respect to *station*, as it is distinguished from riches, whether it confer authority over others, or be invested with honours which apply solely to sentiment and imagination, the truth is, that what is gained by rising through the ranks of life is not more than sufficient to draw forth the exertions of those who are engaged in the pursuits which lead to advancement, and which, in general, are such as ought to be encouraged. Distinctions of this sort are subjects much more of competition than of enjoyment; and in that competition their use consists. It is not, as hath been rightly observed, by what the *lord mayor* feels in his coach, but by what the *apprentice* feels who gazes at him, that the public is served.

As we approach the summits of human greatness, the comparison of good and evil, with respect to personal comfort, becomes still more problematical, even allowing to ambition all its pleasures. The poet asks, "What is grandeur, what is power?" The philosopher answers, "Constraint and plague: *et in maximâ quâque fortunâ minimum licere.*" One very common error misleads the opinion of mankind on this head, *viz.*: that, universally, authority is pleasant, submission painful. In the general course of human affairs, the very reverse of this is nearer the truth. Command is anxiety, obedience ease.

Artificial distinctions sometimes promote real equality. Whether they be hereditary, or be the homage paid to office, or the respect attached by public opinion to particular professions, they serve to *confront* that grand and unavoidable distinction which arises from property, and which is most overbearing where there is no other. It is of the nature of property, not only to be irregularly distributed, but to run into large masses. Public laws should be so constructed as to favour its diffusion as much as they can. But all that can be done by laws, consistently with that degree of government of his property which ought to be left to the subject, will not be sufficient to coun-

teract this tendency. There must always, therefore, be the difference between rich and poor; and this difference will be the more grinding when no pretension is allowed to be set up against it.

So that the evils, if evils they must be called, which spring either from the necessary subordinations of civil life, or from the distinctions which have naturally, though not necessarily, grown up in most societies, so long as they are unaccompanied by privileges injurious or oppressive to the rest of the community, are such as may, even by the most depressed ranks, be endured with very little prejudice to their comfort.

The mischiefs of which mankind are the occasion to one another, by their private wickednesses and cruelties; by tyrannical exercises of power; by rebellions against just authority; by wars; by national jealousies and competitions operating to the destruction of third countries; or by other instances of misconduct either in individuals or societies, are all to be resolved into the character of man as a *free agent*. Free agency, in its very essence, contains liability to abuse. Yet, if you deprive man of his free agency, you subvert his nature. You may have order from him and regularity, as you may from the tides or trade-winds; but you put an end to his moral character, to virtue, to merit, to accountableness, to the use, indeed, of reason. To which must be added the observation, that even the bad qualities of mankind have an origin in their good ones. The case is this: Human passions are either necessary to human welfare, or capable of being made, and, in a great majority of instances, in fact made, conducive to its happiness. These passions are strong and general; and, perhaps, would not answer their purpose unless they were so. But strength and generality, when it is expedient that particular circumstances should be respected, become, if left to themselves, excess and misdirection. From which excess and misdirection, the vices of mankind (the causes, no doubt, of much misery) appear to spring. This account, while it shows us the princi-

ple of vice, snows us, at the same time, the province of reason and of self-government; the want also of every support which can be procured to either from the aids of religion; and it shows this without having recourse to any native, gratuitous malignity in the human constitution.[90] Mr. Hume, in his posthumous dialogues, asserts, indeed, of *idleness*, or aversion to labour (which he states to lie at the root of a considerable part of the evils which mankind suffer), that it is simply and merely bad. But how does he distinguish idleness from the love of ease? or is he sure that the love of ease in individuals is not the chief foundation of social tranquillity? It will be found, I believe, to be true, that in every community there is a large class of its members whose idleness is the best quality about them, being the corrective of other bad ones. If it were possible, in every instance, to give a right determination to industry, we could never have too much of it. But this is not possible if men are to be free. And without this, nothing would be so dangerous as an incessant, universal, indefatigable activity. In the civil world as well as in the material, it is the *vis inertiæ* which keeps things in their places.

NATURAL THEOLOGY has ever been pressed with this question—Why, under the regency of a supreme and benevolent Will, should there be in the world so much as there is of the appearance of *chance?*

The question in its whole compass lies beyond our reach: but there are not wanting, as in the origin of evil, answers which seem to have considerable weight

[90] What precisely is meant by "native and gratuitous malignity" in this passage is not clear. Certain it is that it is difficult to account for all the injustice, vice, and crime among men, on the supposition that they come into life under the influence of none but good propensities. It may be doubted whether, in order to solve this phenomenon, as well as to do justice to the Divine character, we do not need the hypothesis of man's original apostacy; an hypothesis which seems to be pretty clearly established by nature as well as by revelation.—*Am. Ed.*

in particular cases, and also to embrace a considerable number of cases.

I. There must be *chance* in the midst of design: by which we mean, that events which are not designed necessarily arise from the pursuit of events which are designed. One man travelling to York meets another man travelling to London. Their meeting is by chance, is accidental, and so would be called and reckoned, though the journeys which produced the meeting were, both of them, undertaken with design and from deliberation. The meeting, though accidental, was nevertheless hypothetically necessary (which is the only sort of necessity that is intelligible): for if the two journeys were commenced at the time, pursued in the direction, and with the speed in which and with which they were in fact begun and performed, the meeting could not be avoided. There was not, therefore, the less necessity in it for its being by chance. Again, the rencounter might be most unfortunate, though the errand upon which each party set out upon his journey were the most innocent or the most laudable. The by effect may be unfavourable, without impeachment of the proper purpose, for the sake of which the train, from the operations of which these consequences ensued, was put in motion. Although no cause act without a good purpose, accidental consequences like these may be either good or bad.

II. The *appearance of chance* will always bear a proportion to the ignorance of the observer. The cast of a die as regularly follows the laws of motion as the going of a watch; yet, because we can trace the operation of those laws through the works and movements of the watch, and cannot trace them in the shaking or throwing of the die (though the laws be the same, and prevail equally in both cases), we call the turning up of the number of the die chance, the pointing of the index of the watch machinery, order, or by some name which excludes chance. It is the same in those events which depend upon the will of a free and rational agent. The verdict of a jury,

the sentence of a judge, the resolution of an assembly, the issue of a contested election, will have more or less the appearance of chance, might be more or less the subject of a wager, according as we were less or more acquainted with the reasons which influenced the deliberation. The difference resides in the information of the observer, and not in the thing itself; which, in all the cases proposed, proceeds from intelligence, from mind, from counsel, from design.[91]

Now, when this one cause of the appearance of chance, *viz.*, the ignorance of the observer, comes to be applied to the operations of the Deity, it is easy to foresee how fruitful it must prove of difficulties and of seeming confusion. It is only to think of the Deity, to perceive what variety of objects, what distance of time, what extent of space and action, his counsels may, or, rather, must comprehend. Can it be wondered at, that, of the purposes which dwell in such a mind as this, so small a part should be known to us? It is only necessary, therefore, to bear in our thought, that in proportion to the inadequateness of our information will be the quantity in the world of apparent chance.

III. In a great variety of cases, and of cases comprehending numerous subdivisions, it appears, for many reasons, to be better that events rise up by *chance*, or, more properly speaking, with the appearance of chance, than according to any observable rule whatever. This is not seldom the case even in human arrangements. Each person's place and precedence in a public meeting may be determined by *lot*. Work and labour may be *allotted*. Tasks and burdens may be *allotted:*

> "Operumque laborem
> Partibus æquabat justis, aut *sorte* trahebat."

Military service and station may be *allotted*. The distribution of provision may be made by *lot*, as it is

[91] See note to page 87 of the former volume, respecting Chance. This paragraph is wholly free from the inaccuracy taken notice of in the former note.

in a sailor's mess; in some cases also, the distribution of favours may be made by *lot*. In all these cases, it seems to be acknowledged that there are advantages in permitting events to chance superior to those which would or could arise from regulation. In all these cases also, though events rise up in the way of chance, it is by appointment that they do so.

In other events, and such as are independent of human will, the reasons for this preference of uncertainty to rule appear to be still stronger. For example: it seems to be expedient that the period of human life should be *uncertain*. Did mortality follow any fixed rule, it would produce a security in those that were at a distance from it which would lead to the greatest disorders; and a horror in those who approached it similar to that which a condemned prisoner feels on the night before his execution. But, that death be uncertain, the young must sometimes die as well as the old. Also, were deaths never *sudden*, they who are in health would be too confident of life. The strong and the active, who want most to be warned and checked, would live without apprehension or restraint. On the other hand, were sudden deaths very frequent, the sense of constant jeopardy would interfere too much with the degree of ease and enjoyment intended for us, and human life be too precarious for the business and interests which belong to it. There could not be dependance either upon our own lives, or the lives of those with whom we were connected, sufficient to carry on the regular offices of human society. The manner, therefore, in which death is made to occur, conduces to the purposes of admonition, without overthrowing the necessary stability of human affairs.[92]

[92] It must never be forgotten that, according to the scheme, whether of Natural or of Revealed Religion, the doctrine of a Future State removes one branch of the evil here treated of, and answers the common skeptical objection grounded upon the destruction of one being made the means of benefit to another. In the view of religion, the person removed by Providence is to be considered as suffering no loss whatever; he is at once taken to a superior state. The survivers alone are to be considered as regards the question of evil.

Disease being the forerunner of death, there is the same reason for its attacks coming upon us under the appearance of chance, as there is for uncertainty in the time of death itself.

The *seasons* are a mixture of regularity and chance. They are regular enough to authorize expectation, while their being, in a considerable degree, irregular, induces, on the part of the cultivators of the soil, a necessity for personal attendance, for activity, vigilance, precaution. It is this necessity which creates farmers; which divides the profit of the soil between the owner and the occupier; which, by requiring expedients, by increasing employment, and by rewarding expenditure, promotes agricultural arts and agricultural life, of all modes of life the best, being the most conducive to health, to virtue, to enjoyment. I believe it to be found, in fact, that where the soil is the most fruitful and the seasons the most constant, there the condition of the cultivators of the earth is the most depressed. Uncertainty, therefore, has its use even to those who sometimes complain of it the most. Seasons of scarcity themselves are not without their advantages.[93] They call forth new exertions; they set contrivance and ingenuity at work: they give birth to improvements in agriculture and economy; they promote the investigation and management of public resources.

Again: there are strong intelligible reasons why there should exist in human society great disparity of *wealth* and *station;* not only as these things are acquired in different degrees, but at the first setting out of life. In order, for instance, to answer the various demands of civil life, there ought to be among the members of every civil society a diversity of education, which can only belong to an original diversity of circumstances. As this sort of disparity, which ought to take place from the beginning of life, must, *ex hypothesi*, be previous to the merit or demerit of the persons upon whom it falls, can it be better disposed

[93] See former note upon the only legitimate application of such arguments.

of than by chance? *Parentage* is that sort of chance: yet it is the commanding circumstance which, in general, fixes each man's place in civil life, along with everything which appertains to its distinctions. It may be the result of a beneficial rule, that the fortunes or honours of the father devolve upon the son; and, as it should seem, of a still more necessary rule, that the low or laborious condition of the parent be communicated to his family; but, with respect to the successor himself, it is the drawing of a ticket in a lottery. Inequalities, therefore, of fortune, at least the greatest part of them, *viz.*, those which attend us from our birth, and depend upon our birth, may be left, as they are left, to *chance*, without any just cause for questioning the regency of a supreme Disposer of events.

But not only the donation, when, by the necessity of the case, they must be gifts, but even the *acquirability* of civil advantages, ought, perhaps, in a considerable degree, to lie at the mercy of chance. Some would have all the virtuous rich, or, at least, removed from the evils of poverty, without perceiving, I suppose, the consequence, that all the poor must be wicked. And how such a society could be kept in subjection to government has not been shown: for the poor, that is, they who seek their subsistence by constant manual labour, must still form the mass of the community; otherwise the necessary labour of life could not be carried on; the work could not be done, which the wants of mankind in a state of civilization, and, still more, in a state of refinement, require to be done.[94]

[94] The "mass of the community" must labour, but it is not so evident that, in a well-ordered society, they must be poor. If all did labour; if that labour were well directed; and if its results were properly distributed and duly economized, one can see no reason why the mass of the community should not be in circumstances much more comfortable than those indicated by the author when he describes them as seeking subsistence by *constant manual labour*. Labour has other and higher ends than to procure a mere subsistence, and it is to be regretted that writers so frequently refer to it as if it were a hard necessity rather than a privilege.—*Am. Ed.*

It appears to be also true, that the exigencies of social life call not only for an original diversity of *external* circumstances, but for a mixture of different faculties, tastes, and tempers. Activity and contemplation, restlessness and quiet, courage and timidity, ambition and contentedness, not to say even indolence and dulness, are all wanted in the world, all conduce to the well going on of human affairs, just as the rudder, the sails, and the ballast of a ship all perform their part in the navigation. Now, since these characters require for their foundation different original talents, different dispositions, perhaps also different bodily constitutions; and since, likewise, it is apparently expedient that they be promiscuously scattered among the different classes of society, can the distribution of talents, dispositions, and the constitutions upon which they depend be better made than by *chance?*

The *opposites* of apparent chance are constancy and sensible interposition, every degree of *secret* direction being consistent with it. Now of *constancy*, or of fixed and known rules, we have seen in some cases the inapplicability; and inconveniences which we do not see might attend their application in other cases.

Of *sensible* interposition we may be permitted to remark, that a Providence, always and certainly distinguishable, would be neither more nor less than miracles rendered frequent and common. It is difficult to judge of the state into which this would throw us. It is enough to say that it would cast us upon a quite different dispensation from that under which we live. It would be a total and radical change; and the change would deeply affect, or, perhaps, subvert the whole conduct of human affairs. I can readily believe that, other circumstances being adapted to it, such a state might be better than our present state. It may be the state of other beings; it may be ours hereafter. But the question with which we are now concerned is, how far it would be consistent with our condition, supposing it in other respects to remain as

it is? And in this question there seem to be reasons of great moment on the negative side. For instance: so long as bodily labour continues, on so many accounts, to be necessary for the bulk of mankind, any dependance upon supernatural aid, by unfixing those motives which promote exertion, or by relaxing those habits which engender patient industry, might introduce negligence, inactivity, and disorder into the most useful occupations of human life, and thereby deteriorate the condition of human life itself.[95]

As moral agents we should experience a still greater alteration, of which more will be said under the next article.

Although, therefore, the Deity, who possesses the power of winding and turning, as he pleases, the course of causes which issue from himself, do in fact interpose to alter or intercept effects which, without such interposition, would have taken place; yet it is by no means incredible that his Providence, which always rests upon final good, may have made a *reserve* with respect to the manifestation of his interference a part of the very plan which he has appointed for our terrestrial existence, and a part conformable with, or in some sort required by, other parts of the same plan. It is, at any rate, evident that a large and ample province remains for the exercise of Providence without its being naturally perceptible by us; because obscurity, when applied to the interruption of laws, bears a necessary proportion to the imperfection of our knowledge when applied to laws themselves, or, rather, to the effects which these laws, under their various and incalculable combinations, would of their own accord produce. And if it be said that the doctrine of Divine Providence, by reason of the ambiguity under which its exertions present themselves, can be attended with no *practical* influence upon our conduct; that, although we believe ever so firmly that there is a Providence, we must prepare, and provide, and act as if there

[95] This remark applies to mental as well as to bodily labour.—*Am. Ed.*

were none; I answer that this is admitted; and that we farther allege, that so to prepare and so to provide is consistent with the most perfect assurance of the reality of a Providence: and not only so, but that it is, probably, one advantage of the present state of our information that our provisions and preparations are not disturbed by it. Or, if it be still asked, "Of what use at all, then, is the doctrine, if it neither alter our measures nor regulate our conduct?" I answer again that it is of the greatest use, but that it is a doctrine of sentiment and piety, not (immediately at least) of action or conduct; that it applies to the consolation of men's minds, to their devotions, to the excitement of gratitude, the support of patience, the keeping alive and the strengthening of every motive for endeavouring to please our Maker; and that these are great uses.[96]

[96] The views taken in these three paragraphs are most important, and they lead to another of equal moment (if, indeed, they do not include it), respecting the obscurity which hangs over the subject of a future state. Skeptics have constantly asked, "Why a matter, beyond all comparison the most important and the most interesting to man, should be left in any the least doubt?" in other words, "Why the combined operation of natural and revealed religion should not be to make us just as certain of what shall befall us upon our removal from this world, as we are of what is likely to happen on the morrow of any given day?" The answer is, *because* this matter is so immeasurably more important and more interesting to us than all others; and *because*, unless our whole nature were changed, the absolute certainty of enjoyments [or misery] without end and without limit would make the performance of our present task impossible. If, indeed, the farther question is pressed, "Why are we so constituted?" this is only another form of what, in truth, all these reasonings conceal, the question, "Why man was created a finite being?" For in this all the skeptical questions of the description adverted to invariably end. Thus, to take an instance from one gratification which of necessity presupposes evil: There is pleasure in the cessation of pain, and in the enjoyment of rest after labour, as there also is in satisfying the thirst for knowledge. It is not a contingent, but a necessary truth, that this gratification of ease or of curiosity satisfied cannot be obtained without the preceding evil of suffering or fatigue, or the preceding imperfection of ignorance. But it is said, "Why might we not have been so made as to have other equal pleasures without the evil?" And, had such been our con-

Of all views under which human life has ever been considered, the most reasonable, in my judgment, is that which regards it as a state of *probation*. If the course of the world was separated from the contrivances of nature, I do not know that it would be necessary to look for any other account of it than what, if it may be called an account, is contained in the answer, that events rise up by chance. But since the contrivances of nature decidedly evince *intention*; and since the course of the world and the contrivances of nature have the same author, we are, by the force of this connexion, led to believe that the appearance under which events take place is reconcilable with the supposition of design on the part of the Deity. It is enough that they be reconcilable with this supposition; and it is undoubtedly true that they may be reconcilable, though we cannot reconcile them. The mind, however, which contemplates the works of nature, and in those works sees so much of means directed to ends, of beneficial effects brought about by wise expedients, of concerted trains of causes terminating in the happiest results; so much, in a word, of counsel, intention, and benevolence; a mind, I say, drawn into the habit of thought, which these observations excite, can hardly turn its view to the condition of our own spe-

stitution, the same objectors would have said, "Here is one source of enjoyment cut off." Nay, if life were an alternation of positive enjoyment with mere ease, they would still say, "Why any interval of positive enjoyment, compared with which mere ease is worthless, and so an evil?" And if all were positive enjoyment, they would say, "Why is it not more exquisite?" In other words, "Why is man a finite being?" All our speculations, however, upon this subject must proceed upon the assumption that the design of Providence was to create a finite mortal creature, endowed with free will, but influenced by motives inducing and dissuading. Any inquiry into the reason for such a determination being taken by the Supreme Being far exceeds the bounds of our faculties; and the question as to evil must be always handled with the impression that, beyond a certain way, we never can make progress towards its entire solution. The whole subject, with the different doctrines held upon it, will be treated at large in the Appendix, where it will be contended that the most enlarged views lead to the conclusion of rational optimism and a probationary state.

cies without endeavouring to suggest to itself some purpose, some design, for which the state in which we are placed is fitted, and which it is made to serve. Now we assert the most probable supposition to be, that it is a state of moral probation; and that many things in it suit with this hypothesis which suit no other. It is not a state of unmixed happiness, or of happiness simply; it is not a state of designed misery, or of misery simply; it is not a state of retribution; it is not a state of punishment. It suits with none of these suppositions. It accords much better with the idea of its being a condition calculated for the production, exercise, and improvement of moral qualities, with a view to a future state, in which these qualities, after being so produced, exercised, and improved, may, by a new and more favourable constitution of things, receive their reward, or become their own. If it be said that this is to enter upon a religious rather than a philosophical consideration, I answer, that the name of Religion ought to form no objection if it shall turn out to be the case that the more religious our views are, the more probability they contain. The degree of beneficence, of benevolent intention and of power, exercised in the construction of sensitive beings, goes strongly in favour, not only of a creative, but of a continuing care, that is, of a ruling Providence. The degree of chance which appears to prevail in the world requires to be reconciled with this hypothesis. Now it is one thing to maintain the doctrine of Providence along with that of a future state, and another thing without it. In my opinion, the two doctrines must stand or fall together. For although more of this apparent chance may perhaps, upon other principles, be accounted for than is generally supposed, yet a future state alone rectifies all disorders; and if it can be shown that the appearance of disorder is consistent with the uses of life as a *preparatory* state, or that in some respects it promotes these uses, then, so far as this hypothesis may be accepted, the ground of the difficulty is done away.

In the wide scale of human condition there is not, perhaps, one of its manifold diversities which does not bear upon the design here suggested. Virtue is infinitely various. There is no situation in which a rational being is placed, from that of the best-instructed Christian down to the condition of the rudest barbarian, which affords not room for moral agency; for the acquisition, exercise, and display of voluntary qualities, good and bad. Health and sickness, enjoyment and suffering, riches and poverty, knowledge and ignorance, power and subjection, liberty and bondage, civilization and barbarity, have all their offices and duties, all serve for the *formation* of character: for, when we speak of a state of trial, it must be remembered that characters are not only tried, or proved, or detected, but that they are generated also, and *formed* by circumstances. The best dispositions may subsist under the most depressed, the most afflicted fortunes. A West Indian slave, who, amid his wrongs, retains his benevolence, I, for my part, look upon as among the foremost of human candidates for the rewards of virtue. The kind master of such a slave: that is, he who, in the exercise of an inordinate authority, postpones, in any degree, his own interest to his slave's comfort, is likewise a meritorious character; but still he is inferior to his slave. All, however, which I contend for is, that these destinies, opposite as they may be in every other view, are both *trials*, and equally such. The observation may be applied to every other condition: to the whole range of the scale, not excepting even its lowest extremity. *Savages* appear to us all alike; but it is owing to the distance at which we view savage life that we perceive in it no discrimination of character. I make no doubt but that moral qualities, both good and bad, are called into action as much, and that they subsist in as great variety in these inartificial societies as they are or do in polished life. Certain at least it is, that the good and ill treatment which each individual meets with, depends more upon the choice and voluntary conduct of those about him, than it does or ought to

do under regular civil institutions and the coercion of public laws. So, again, to turn our eyes to the other end of the scale: namely, that part of it which is occupied by mankind enjoying the benefits of learning, together with the lights of revelation; there, also, the advantage is all along *probationary*. Christianity itself, I mean the revelation of Christianity, is not only a blessing, but a trial. It is one of the diversified means by which the character is exercised: and they who require of Christianity that the revelation of it should be universal, may possibly be found to require that one species of probation should be adopted, if not to the exclusion of others, at least to the narrowing of that variety which the wisdom of the Deity hath appointed to this part of his moral economy.*

Now if this supposition be well-founded: that is, if it be true that our ultimate or our most permanent happiness will depend, not upon the temporary condition into which we are cast, but upon our behaviour in it, then is it a much more fit subject of *chance* than we usually allow or apprehend it to be, in what manner the variety of external circumstances which subsist in the human world is distributed among the individuals of the species. "This life being a state of probation, it is immaterial," says Rousseau, "what kind of trials we experience in it, provided they produce their effects." Of two agents who stand indifferent to the moral Governor of the universe, one may be exercised by riches, the other by poverty. The treatment of these two shall appear to be very opposite, while in truth it is the same; for though, in many respects, there be great disparity between the

* The reader will observe that I speak of the revelation of Christianity as distinct from Christianity itself. The *dispensation* may already be universal. That part of mankind which never heard of CHRIST's name may nevertheless be redeemed: that is, be placed in a better condition, with respect to their future state, by his intervention; may be the objects of his benignity and intercession, as well as of the propitiatory virtue of his passion. But this is not "natural theology;" therefore I will not dwell longer upon it.—*Note of the Author.*

conditions assigned, in one main article there may be none, *viz.*, in that they are alike trials; have both their duties and temptations, not less arduous or less dangerous in one case than the other; so that if the final award follow the character, the original distribution of the circumstances under which that character is formed may be defended upon principles not only of justice, but of equality. What hinders, therefore, but that mankind may draw lots for their condition? They take their portion of faculties and opportunities, as any unknown cause or concourse of causes, or as causes acting for other purposes may happen to set them out: but the event is governed by that which depends upon themselves, the application of what they have received. In dividing the talents no rule was observed: none was necessary: in rewarding the use of them, that of the most correct justice. The chief difference at last appears to be, that the right use of more talent, *i. e.*, of a greater trust, will be more highly rewarded than the right use of fewer talents, *i. e.*, of a less trust. And since, for other purposes, it is expedient that there be an inequality of concredited talents here, as well probably as an inequality of conditions hereafter, though all remuneratory, can any rule adapted to that inequality be more agreeable, even to our apprehensions of distributive justice, than this is?

We have said that the appearance of *casualty* which attends the occurrences and events of life, not only does not interfere with its uses as a state of probation, but that it promotes these uses.

Passive virtues, of all others the severest and the most sublime; of all others, perhaps, the most acceptable to the Deity, would, it is evident, be excluded from a constitution in which happiness and misery regularly followed virtue and vice. Patience and composure under distress, affliction, and pain; a steadfast keeping up of our confidence in God, and of our reliance upon his final goodness, at the time when everything present is adverse and discouraging; and (what is no less difficult to retain) a cordial desire

for the happiness of others, even when we are deprived of our own; these dispositions, which constitute, perhaps, the perfection of our moral nature, would not have found their proper office and object in a state of avowed retribution; and in which, consequently, endurance of evil would be only submission to punishment.

Again: one man's sufferings may be another man's trial. The family of a sick parent is a school of filial piety. The charities of domestic life, and not only these, but all the social virtues, are called out by distress. But then misery, to be the proper object of mitigation, or of that benevolence which endeavours to relieve, must be really or apparently casual. It is upon such sufferings alone that benevolence can operate. For, were there no evils in the world but what were punishments, properly and intelligibly such, benevolence would only stand in the way of justice. Such evils, consistently with the administration of moral government, could not be prevented or alleviated; that is to say, could not be remitted in whole or in part, except by the authority which inflicted them, or by an appellate or superior authority. This consideration, which is founded in our most acknowledged apprehensions of the nature of penal justice, may possess its weight in the Divine counsels. Virtue, perhaps, is the greatest of all ends. In human beings, relative virtues form a large part of the whole. Now relative virtue presupposes not only the existence of evil, without which it could have no object, no material to work upon, but that evils be apparently, at least, *misfortunes*; that is, the effects of apparent chance. It may be in pursuance, therefore, and in furtherance of the same scheme of probation, that the evils of life are made so to present themselves.

I have already observed, that when we let in religious considerations, we often let in light upon the difficulties of nature. So in the fact now to be accounted for, the *degree* of happiness which we usually enjoy in this life may be better suited to a state of trial and probation than a greater degree would be.

The truth is, we are rather too much delighted with the world than too little. Imperfect, broken, and precarious as our pleasures are, they are more than sufficient to attach us to the eager pursuit of them. A regard to a *future* state can hardly keep its place as it is. If we were designed, therefore, to be influenced by that regard, might not a more indulgent system, a higher or more uninterrupted state of gratification, have interfered with the design? At least it seems expedient that mankind should be susceptible of this influence when presented to them; that the condition of the world should not be such as to exclude its operation, or even to weaken it more than it does. In a religious view (however we may complain of them in every other), privation, disappointment, and satiety are not without the most salutary tendencies.

CHAPTER XXVII.

CONCLUSION.

In all cases wherein the mind feels itself in danger of being confounded by variety, it is sure to rest upon a few strong points, or perhaps upon a single instance. Among a multitude of proofs, it is *one* that does the business. If we observe in any argument that hardly two minds fix upon the same instance, the diversity of choice shows the strength of the argument, because it shows the number and competition of the examples. There is no subject in which the tendency to dwell upon select or single topics is so usual, because there is no subject of which, in its full extent, the latitude is so great as that of natural history applied to the proof of an intelligent Creator. For my part, I take my stand in human anatomy; and the examples of mechanism I should be apt to draw out from the copious catalogue which it supplies, are the

pivot upon which the head turns, the ligaments within the socket of the hip-joint, the pulley or trochlear muscles of the eye, the epiglottis, the bandages which tie down the tendons of the wrist and instep, the slit or perforated muscles at the hands and feet, the knitting of the intestines to the mesentery, the course of the chyle into the blood, and the constitution of the sexes as extended throughout the whole of the animal creation. To these instances the reader's memory will go back, as they are severally set forth in their places: there is not one of the number which I do not think decisive; not one which is strictly mechanical: nor have I read or heard of any solution of these appearances which in the smallest degree shakes the conclusion that we build upon them.

But of the greatest part of those who, either in this book or any other, read arguments to prove the existence of a God, it will be said that they leave off only where they began; that they were never ignorant of this great truth, never doubted of it; that it does not therefore appear what is gained by researches from which no new opinion is learned, and upon the subject of which no proofs were wanted. Now I answer that, by *investigation*, the following points are always gained in favour of doctrines even the most generally acknowledged (supposing them to be true), *viz.*, stability and impression. Occasions will arise to try the firmness and opinions. And upon these occasions it is a matter of incalculable use to feel our foundation; to find a support in argument for what we had taken up upon authority. In the present case, the arguments upon which the conclusion rests are exactly such as a truth of universal concern ought to rest upon. "They are sufficiently open to the views and capacities of the unlearned, at the same time that they acquire new strength and lustre from the discoveries of the learned." If they had been altogether abstruse and recondite, they would not have found their way to the understandings of the mass of mankind; if they had been merely popular, they might have wanted solidity.

But, secondly, what is gained by research in the stability of our conclusion, is also gained from it in *impression*.[97] Physicians tell us that there is a great deal of difference between taking a medicine and the medicine getting into the constitution. A difference not unlike which obtains with respect to those great moral propositions, which ought to form the directing principles of human conduct. It is one thing to assent to a proposition of this sort; another, and a very different thing, to have properly imbibed its influence.

[97] We have adverted in a former note (chap. xxv.) to the lamented silence of La Place upon the inferences to which his most important researches so naturally lead. An objection of a kind in some respects similar, but in others materially different, has often been urged against another class of writers; the historians who record, without observation, events in which pious men are prone to trace the interposition of Providence. This charge was brought, upon one remarkable occasion, against the narrative of a celebrated voyage of discovery; and the author, Dr. Hawkesworth, defended himself in an elaborate and ingenious manner: he urged that either the event (the ceasing of the wind at a critical moment, by which Captain Cook's ship, after it had struck on a coral rock, was saved, contrary to all expectation) happened in the ordinary course of nature, and then ought no more to be called providential than the rising of the sun upon any given day; or it was produced by an extraordinary interposition, and then the same power might have rendered this unnecessary by preventing the ship from striking.—(Voyages, vol. i., p. xxi., second edition.) But this reasoning proceeds upon an entire misapprehension of the objection. No one denies that the good and the evil come from the same Almighty hand; but, resting in the belief avowed by Dr. Hawkesworth himself, in explicit terms, that "the Supreme Being is equally wise and benevolent in the dispensation of both evil and good as means of effecting ultimate purposes worthy of his ineffable perfections" (*ib.*, p. xx.), we may, with the most absolute consistency, express thankfulness for the one, and resigned submission to the other dispensation; and it is a wholesome habit of thinking, and one according with our duty to that awful and benevolent Being, as well as conducive to our own mental improvement, to make our gratitude for his bounties keep pace with our resignation to his will. Those, therefore, who, like La Place, pass by an occasion of marking the proofs of his existence and intelligence where it naturally presents itself, expose themselves to blame; and those who, as it were, go out of their way to avoid marking instances of his bounty, are alike censurable. Both classes neglect a fit opportunity of promoting human improvement.

I take the case to be this: perhaps almost every man living has a particular train of thought, into which his mind glides and falls when at leisure from the impressions and ideas that occasionally excite it: perhaps, also, the train of thought here spoken of, more than any other thing, determines the character. It is of the utmost consequence, therefore, that this property of our constitution be well regulated. Now it is by frequent or continued meditation upon a subject, by placing a subject in different points of view, by induction of particulars, by variety of examples, by applying principles to the solution of phenomena, by dwelling upon proofs and consequences, that mental exercise is drawn into any particular channel. It is by these means, at least, that we have any power over it. The train of spontaneous thought, and the choice of that train, may be directed to different ends, and may appear to be more or less judiciously fixed, according to the purpose in respect of which we consider it: but, in a *moral view*, I shall not, I believe, be contradicted when I say that, if one train of thinking be more desirable than another, it is that which regards the phenomena of nature with a constant reference to a supreme intelligent Author. To have made this the ruling, the habitual sentiment of our minds, is to have laid the foundation of everything which is religious. The world thenceforth becomes a temple, and life itself one continued act of adoration. The change is no less than this; that, whereas formerly God was seldom in our thoughts, we can now scarcely look upon anything without perceiving its relation to him. Every organized natural body, in the provisions which it contains for its sustentation and propagation, testifies a care on the part of the Creator expressly directed to these purposes. We are on all sides surrounded by such bodies; examined in their parts, wonderfully curious; compared with one another, no less wonderfully diversified. So that the mind, as well as the eye, may either expatiate in variety and multitude, or fix itself down to the investigation of particular divisions of the science. And

in either case it will rise up from its occupation possessed by the subject in a very different manner and with a very different degree of influence from what a mere assent to any verbal proposition which can be formed concerning the existence of the Deity, at least that merely complying assent with which those about us are satisfied, and with which we are too apt to satisfy ourselves, will or can produce upon the thoughts. More especially may this difference be perceived in the degree of admiration and of awe with which the divinity is regarded when represented to the understanding by its own remarks, its own reflections, and its own reasonings, compared with what is excited by any language that can be used by others. The works of nature want only to be contemplated. When contemplated, they have everything in them which can astonish by their greatness: for, of the vast scale of operation through which our discoveries carry us, at one end we see an intelligent power arranging planetary systems, fixing, for instance, the trajectory of *Saturn*, or constructing a ring of two hundred thousand miles diameter to surround his body, and be suspended like a magnificent arch over the heads of his inhabitants; and, at the other, bending a hooked tooth, concerting and providing an appropriate mechanism, for the clasping and reclasping of the filaments of the feather of the humming-bird. We have proof not only of both these works proceeding from an intelligent agent, but of their proceeding from the same agent: for, in the first place, we can trace an identity of plan, a connexion of system, from Saturn to our own globe; and, when arrived upon our globe, we can, in the second place, pursue the connexion through all the organized, especially the animated, bodies which it supports. We can observe marks of a common relation, as well to one another as to the elements of which their habitation is composed. Therefore one mind hath planned, or, at least, hath prescribed, a general plan for all these productions. One Being has been concerned in all.

Under this stupendous Being we live. Our happi-

ness, our existence is in his hand. All we expect must come from him. Nor ought we to feel our situation insecure. In every nature and in every portion of nature which we can descry, we find attention bestowed upon even the minutest parts. The hinges in the wings of an *earwig*, and the joints of its antennæ, are as highly wrought as if the Creator had had nothing else to finish. We see no signs of diminution of care by multiplicity of objects, or of distraction of thought by variety. We have no reason to fear, therefore, our being forgotten, or overlooked, or neglected.[98]

The existence and character of the Deity is, in every view, the most interesting of all human speculations. In none, however, is it more so than as it facilitates the belief of the fundamental articles of *Revelation*. It is a step to have it proved that there must be something in the world more than what we see. It is a farther step to know that, among the invisible things of nature, there must be an intelligent mind concerned in its production, order, and support. These points being assured to us by Natural Theology, we may well leave to Revelation the disclosure of many particulars which our researches cannot reach, respecting either the nature of this being as the original cause of all things, or his character and designs as a moral governor; and not only so, but the more full confirmation of other particulars, of which, though they do not lie altogether beyond our reasonings and our probabilities, the certainty is by no means

[98] There is assuredly nothing that more tends to absorb our whole faculties in devout admiration than the contemplation of that universal power and pervading skill which is here remarked by the author. The same being that fashioned the insect whose existence is only discerned by a microscope, and gave that invisible speck a system of ducts and other organs to perform its vital functions, created the enormous mass of the planet thirteen hundred times larger than our earth, and launched it in its course round the sun; and the comet, wheeling with a velocity that would carry it round our globe in less than two minutes of time, and yet revolving through so prodigious a space that it takes near six centuries to encircle the sun!

equal to the importance. The true theist will be the first to listen to *any* credible communication of Divine knowledge. Nothing which he has learned from Natural Theology will diminish his desire of future instruction, or his disposition to receive it with humility and thankfulness. He wishes for light: he rejoices in light. His inward veneration of this great Being will incline him to attend with the utmost seriousness not only to all that can be discovered concerning him by researches into nature, but to all that is taught by a revelation which gives reasonable proof of having proceeded from him.

But, above every other article of revealed religion, does the anterior belief of a Deity bear with the strongest force upon that grand point, which gives indeed interest and importance to all the rest, the resurrection of the human dead. The thing might appear hopeless did we not see a power at work adequate to the effect, a power under the guidance of an intelligent will, and a power penetrating the inmost recesses of all substance. I am far from justifying the opinion of those who "thought it a thing incredible that God should raise the dead:" but I admit that it is first necessary to be persuaded that there *is* a God to do so. This being thoroughly settled in our minds, there seems to be nothing in this process (concealed as we confess it to be) which need to shock our belief. They who have taken up the opinion that the acts of the human mind depend upon *organization*, that the mind itself indeed consists in organization, are supposed to find a greater difficulty than others do in admitting a transition by death to a new state of sentient existence, because the old organization is apparently dissolved. But I do not see that any impracticability need be apprehended even by these; or that the change, even upon their hypothesis, is far removed from the analogy of some other operations which we know with certainty that the Deity is carrying on. In the ordinary derivation of plants and animals from one another, a particle in many cases minuter than all assignable, all

conceivable dimension—an aura, an effluvium, an infinitesimal—determines the organization of a future body: does no less than fix whether that which is about to be produced shall be a vegetable, a merely sentient, or a rational being; an oak, a frog, or a philosopher; makes all these differences; gives to the future body its qualities, and nature, and species. And this particle, from which springs, and by which is determined a whole future nature, itself proceeds from, and owes its constitution to a prior body: nevertheless, which is seen in plants most decisively, the incepted organization, though formed within, and through, and by a preceding organization, is not corrupted by its corruption or destroyed by its dissolution; but, on the contrary, is sometimes extricated and developed by those very causes; survives and comes into action when the purpose for which it was prepared requires its use. Now an economy which nature has adopted, when the purpose was to transfer an organization from one individual to another, may have something analogous to it when the purpose is to transmit an organization from one state of being to another state: and they who found thought in organization may see something in this analogy applicable to their difficulties; for whatever can transmit a similarity of organization will answer their purpose, because, according even to their own theory, it may be the vehicle of consciousness, and because consciousness carries identity and individuality along with it through all changes of form or of visible qualities. In the most general case, that, as we have said, of the derivation of plants and animals from one another, the latent organization is either itself similar to the old organization, or has the power of communicating to new matter the old organic form. But it is not restricted to this rule. There are other cases, especially in the progress of insect life, in which the dormant organization does not much resemble that which encloses it, and still less suits with the situation in which the enclosing body is placed, but suits with a different situation to

which it is destined. In the larva of the libellula, which lives constantly, and has still long to live under water, are descried the wings of a fly, which two years afterward is to mount into the air. Is there nothing in this analogy? It serves at least to show that, even in the observable course of nature, organizations are formed one beneath another; and, among a thousand other instances, it shows completely that the Deity can mould and fashion the parts of material nature so as to fulfil any purpose whatever which he is pleased to appoint.

They who refer the operation of mind to a substance totally and essentially different from matter (as most certainly these operations, though affected by material causes, hold very little affinity to any properties of matter with which we are acquainted), adopt perhaps a juster reasoning and a better philosophy: and by these the considerations above suggested are not wanted, at least in the same degree. But to such as find, which some persons do find, an insuperable difficulty in shaking off an adherence to those analogies which the corporeal world is continually suggesting to their thoughts, to such I say, every consideration will be a relief which manifests the extent of that intelligent power which is acting in nature, the fruitfulness of its resources, the variety, and aptness, and success of its means; most especially every consideration which tends to show that, in the translation of a conscious existence, there is not, even in their own way of regarding it, anything greatly beyond or totally unlike what takes place in such parts (probably small parts) of the order of nature as are accessible to our observation.

Again: if there be those who think that the contractedness and debility of the human faculties in our present state seem ill to accord with the high destinies which the expectations of religion point out to us, I would only ask them whether any one who saw a child two hours after its birth could suppose that it would ever come to understand *fluxions*;* or

* See Search's Light of Nature, *passim*.

who then shall say what farther amplification of intellectual powers, what accession of knowledge, what advance and improvement, the rational faculty, be its constitution what it will, may not admit of, when placed amid new objects, and endowed with a sensorium adapted, as it undoubtedly will be, and as our present senses are, to the perception of those substances and of those properties of things with which our concern may lie.

Upon the whole, in everything which respects this awful, but, as we trust, glorious change, we have a wise and powerful Being (the author, in nature, of infinitely various expedients for infinitely various ends), upon whom to rely for the choice and appointment of means adequate to the execution of any plan which his goodness or his justice may have formed, for the moral and accountable part of his terrestrial creation. That great office rests with *him;* be it *ours* to hope and to prepare, under a firm and settled persuasion, that, living and dying, we are his; that life is passed in his constant presence, that death resigns us to his merciful disposal.

APPENDIX:

CONTAINING ADDITIONAL

NOTES AND ILLUSTRATIONS

TO

PALEY'S

NATURAL THEOLOGY.

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[Some of the Additional Notes in the English edition are omitted in the present edition, their substance having been condensed in shorter notes, and attached to the corresponding passages of the original text.]

APPENDIX.

I.

ON CHAPTERS I. AND II., AND INTRODUCTORY TO THE MECHANISM OF THE FRAME.

Archdeacon Paley has, in these two introductory chapters, given us the advantage of simple but forcible language, with extreme ingenuity in illustration. But for his example we should have felt some hesitation in making so close a comparison between design, as exhibited by the Creator in the animal structure, and the mere mechanism, the operose and imperfect contrivances of human art.

Certainly there may be a comparison; for a superficial and rapid survey of the animal body may convey the notion of an apparatus of levers, pulleys, and ropes, which may be compared with the spring, barrel, and fusee, the wheels and pinions of a watch. But, if we study the structure of animal bodies more curiously, and especially if we compare animals with each other—for example, the simple structure of the lower creatures with the complicated structure of those higher in the scale of existence—we shall see that in the lowest links of the chain animals are so simple that we should almost call them homogeneous; and yet in these we find life, sensibility, and motion. It is in the animals higher in the scale that we discover parts having distinct endowments, and exhibiting complex mechanical relations. The mechanical contrivances which are so obvious in man, for instance, are the provisions for the agency and dominion of an intellectual power over the materials around him.

We mark this early, because there are authors who, looking upon this complexity of mechanism, confound it with the presence of life itself, and think it a necessary adjunct—nay, even that life proceeds from it: whereas the mechanism which we have to examine in the animal body is formed with reference to the necessity of acting upon, or receiving impressions from, things external to the body; a necessary condition of our state of existence in a material world.

Many have expressed their opinion very boldly on the necessary relation between organization and life, who have never extended their views to the system of nature. To place man, an intelligent and active being, in this world of matter, he must have properties bearing relation to that matter. The existence of matter implies an agency of certain forces; the particles of bodies must suffer attraction and repulsion; and the bodies formed by the balance of these influences upon their atoms or particles must have weight or gravity, and possess mechanical properties. So must the living body, independently of its peculiar endowments, have similar composition and qualities, and have certain relations to the solids, fluids, gases, heat, light, electricity, or galvanism which are around it. Without these, the intellectual principle could receive no impulse, could have no agency and no relation to the material world. The whole body must gravitate or have weight; without which it could neither stand securely, nor exert its powers on the bodies around it. But for this, muscular power itself, and all the appliances which are related to that power, would be useless. When, therefore, it is affirmed that organization or construction is necessary to life, we may at least pause in giving assent, under the certainty that we see another and a different reason for the construction of the body. Thus we perceive, that as the body must have weight to have power, so must it have mechanical contrivance or arrangement of its parts. As it must have weight, so must it be sustained by a skeleton; and when we examine the bones, which give the body height and shape, we find

each column (for in that sense a bone may be first taken) adjusted with the finest attention to the perpendicular weight that it has to bear, as well as to the lateral thrusts to which it is subject in the motions of the body.

The bones also are as levers, on the most accurate mechanical principles. And, while these bones are necessary to give firmness and strength to the frame, it is admirable to observe that one bone never touches another; but a fine elastic material, the cartilage, intervenes between their ends, the effect of which is to give a very considerable degree of elasticity to the whole frame. Without such elasticity a jar would reach the more delicate organs, even in the very recesses of the body, at every violent motion; and, but for this provision, every joint would creak by the attrition of the surfaces of the bones. The bones are surrounded with the flesh or muscles. The muscle is a particular fibrous texture, which alone, of all the materials constituting the frame, possesses the peculiar inherent power or endowment of contracting: it is this power which we are to understand when professional men speak of irritability. The contraction of the muscle bears no proportion to the cause which brings it into operation, more than the touch of the spur upon the horse's side does as a mechanical impetus to the force with which the animal propels both himself and rider. Each muscle of the body—and, by common estimate, there are hundreds—is isolated, and no property of motion is propagated from one to another; they are distinct instruments of motion. The muscles surround the bones, and are so beautifully classed, that in every familiar motion of the limbs some hundreds of them are adjusted in their exact degree to effect the simplest change in the position of the body.

Each fibre of a muscle, and a muscle may contain millions of fibres, is so attached to the tendon that the whole power is concentrated there; and it is the tendons of the muscles which, like ropes, convey the force of the muscles to the bones. The bones are

passive levers; the muscles are the active parts of the frame.

With all the seeming intricacy in the running and crossing of these tendons, they are adjusted accurately on mechanical principles. Where it is necessary, they run in sheaths, or they receive new directions by lateral ligamentous attachments, or there are placed under them smooth and lubricated pulleys over which they run; and, where there is much friction, there is a provision equal in effect to the friction-wheel of machinery.

Thus the bones are levers, with their heads most curiously carved and articulated; and, joined to the intricate relations of the muscles and tendons, they present, on the whole, a piece of perfect mechanism.

It is with this texture—the coarsest, roughest portion of the animal frame—that our author is running a parallel when he compares it with the common mechanical contrivances of machinery. While these grosser parts of the animal body exhibit a perfection in mechanical adaptation far greater than the utmost ingenuity of man can exhibit in his machinery, let the reader remember that they bear no comparison with the finer parts of the animal body; such, for example, as the structure of those nerves which convey the mandate of the will to the moving parts, or of the vessels which are conveying the blood in the circulation, and where the laws of hydraulics may be finely illustrated; or of those secreting glands where, some will affirm, the galvanic influence is in operation with something finer than the apparatus of plates and troughs.

But were we to institute a comparison between the mechanical contrivances of man and these finer mechanisms in the animal frame, we must recollect that there are structures in the body much more admirable, as we shall have abundant opportunities of showing as we proceed in the present volume. The organs of the senses, which are so many inlets for the qualities of surrounding matter to excite corresponding sensations and perceptions, will afford us

delightful subjects of contemplation, and proofs more conclusive of design in the human body; not only in regard to the system of that body itself, but as it forms a part of the system of the universe.

II.

ON DESIGN AS EXHIBITED IN THE MECHANICAL STRUCTURE OF ANIMAL BODIES.

In all animal bodies, besides those structures on which their economy and much of their vital functions depend, there is a firm texture necessary. Without this the vegetable would have no characteristic form; and animals would want the protection necessary for their delicate organs, and could not move upon their extremities. We have to show with what admirable contrivance, in the different classes of organized beings, this firm fabric is reared; sometimes to protect the parts, as a shell, and sometimes to give them form and motion, as in the skeleton.

In vegetables, as in animals, there is a certain firm material necessary to support the parts, which are the living active organs of their system, and which are so beautiful and interesting. The ligneous or woody fibre is a minute, elastic, semi-opaque filament, which, closing in and adhering to other filaments of the same kind, forms the grain or solid part of the wood. The best demonstration of the office of the woody fibre is in the leaf. When the leaf of a plant is prepared by maceration and putrefaction, and the soft part washed away, there remains an elegant skeleton of wood, which retains the form of the leaf, and which is perfectly well suited to support its delicate organization. It is the same substance which, when accumulated and condensed, gives form and strength to the roots and branches of the oak; and these, though fan-

tastic and irregular in their growth, preserve a mechanical principle of strength as obvious to the shipbuilder in the knees of timber as in the delicate skeleton of the leaf. Lord Bacon speaks of "knee-timber, that is good for ships that are to be tossed." The woody fibre, though not directly engaged in the living functions of the tree, is yet essential for extending the branches and leaves to the influence of the atmosphere, and by its elasticity under the pressure of the wind, giving what is equivalent to exercise for the motion of the sap. A tree opposed to winds and to a severe climate is dense in its grain, and the wood is preferred by the workman to that which is the growth of a milder climate.

We cannot miss seeing the analogy of the woody fibre with the bones of animals. Bones are firm to sustain the animal's weight, and to give it form. They are jointed, and move under the action of muscles; and this exercise promotes the activity of the living parts, and is necessary to health. A person of feeble texture and indolent habits has the bone smooth, thin, and light; but nature, solicitous for our safety, in a manner which we could not anticipate, combines with the powerful muscular frame a dense and perfect texture of bone, where every spine and tubercle is completely developed. And thus the inert and mechanical provisions of the bone always bear relation to the living muscular power of the limb, and exercise is as necessary to the perfect constitution and form of a bone as it is to the increase of the muscular power. Jockeys speak correctly enough when they use the term "*blood and bone*" as distinguishing the breed or or genealogy of horses; for blood is an allowable term for the race, and bone is so far significant, that the bone of a running horse is remarkably compact compared with the bone of a draught horse. The reader can easily understand, that in the gallop the horse must come on his fore legs with a shock proportionate to the span; and that in the horse, as in man, the greater the muscular power, the denser and stronger is the bone. The bone not being as

a mere pillar, intended to bear a perpendicular weight, we ought not to expect uniformity in its shape. Each bone, according to its place, bears up against the varying forces that are applied to it. Consider two men wrestling together, and then think how various the direction of the resistances must be: now they are pulling, and the bones are like ropes; or again, they are writhing and twisting, and the bones bear a force like the axle-tree between two wheels; or they are like a pillar under a great weight; or those bones are acting as levers. We see, therefore, why, to withstand these different shocks, a bone should consist, as we have stated, of three parts, the *earth* of bone (sub-phosphate of lime) to give it firmness, *fibres* to give it toughness, and *cartilage* to give it elasticity.

We may pursue this subject a little farther still, taking the text of our author, "*The proportioning of one thing to another.*"—Chap. xvii., sec. v.

The great functions by which animals live, and breathe, and are nourished, are the same through the whole chain, from the simplest polypus or mass of jelly that floats in the sea, to the largest and most complex of all terrestrial creatures. The appetite for food, the powers of assimilation, circulation, aeration, secretion, are the same functions in all living creatures, only modified by their size or condition. When we consider the astonishing variety in the shapes of animated beings, we are apt to forget the necessity of apportioning their size and strength, not only to the vegetable productions and to the materials found on the surface of the earth, but to the magnitude of the globe; to the "great motions that are passing in the heavens." On that plan of living structure which pervades all the varieties of animals in which bones afford resistance and muscles activity, there must be a limit to stature. The resisting parts of the smaller animals, which have an external covering instead of bones, have comparatively much less material in them than the larger. Accordingly, philosophers have contrasted the power of the flea with that of the horse, deciding greatly in favour of the

former. The rationale of this is not quite apparent at first; but a little consideration will convince us that the resisting material being exterior to the animal's body, and, consequently, removed from the centre, it must possess more power against transverse fracture, as well as bestow a mechanical advantage for the action of the muscles. But this is not all: any degree of density and strength may be given to it, from its being a mere secretion, and being unorganized. We may compare, however, the bones of a man with those of the elephant, or other huge animals.* Now it would seem that the material of bone (which we must recollect is porous, since it constitutes a living part, and is nourished by blood-vessels) could not, by any variety of conformation, bear up a greater mass than that of the elephant. On examining the bones of these immense animals, including the megatherium and rhinoceros, they are dense, and strong, and clumsy, as we would term it; their spines and processes are large, and their cavities filled up; all which indicates that, to support a larger animal on extremities, some other material than the vascular bone would be required. Those immense bones that are found in digging the earth, and which, in ignorant ages, have given rise to strange fancies, are the bones of animals inhabiting the water; whales or reptiles, whose bulk was extended in the water, or that crawled on their bellies, and they could never have given support sufficient to have raised their enormous weight on extremities. With regard to the position, that "a chicken roosting on its perch is related to the spheres revolving in the firmament," I have elsewhere illustrated the necessity of a fixed point from which the muscles can act, and that the necessity of resistance implies that of weight, and that that weight must be proportioned to the mass of the globe we inhabit, as well as to the power of the muscular frame.†

* Vol. i., p. 309.

† See the introduction to the Bridgewater Treatise on "The Hand."

III.

DESIGN, OR MECHANICAL CONTRIVANCE, AS EXHIBITED IN THE BONES OF THE HEAD AND THEIR JOININGS.

We have elsewhere spoken of the "architecture" of the scull, which, though at first a startling term, has been acquiesced in from the remarkable instances that we have given of design, in comparing the texture and connexion of the bones with the art of the builder and carpenter. The more important the part is to life, the more vital the organ, we find the texture or fabric which protects it the more perfect. The human scull presents us with many curious proofs that the forces or injuries to which it is exposed are calculated and provided against. But we shall take our first examples from the sculls of animals, and here we see that the brain is not covered in the same manner in all, but that in each variety there is a provision against the forces to which the scull is subjected. The scull of a dog is hardly in any respect like the scull of a ram; the bones of the former are thin; the line of union, which is called the *suture*, is simple; it is not provided to withstand percussion: but in the latter animal there is reared over the proper brain-case a series of arched cells of strong bone, and each bone is joined to another by a line serrated, deep, and regular; the mechanical strength of the union always corresponding with the strength of the bones, and the whole being formed into a base suited for the support of the horns, and calculated to sustain the shock when the animal butts with the whole weight and strength.

We might contrast the scull of the ram or goat with that of the tiger, where the strength is in its jaws. This animal, too, has the brain-case small,

The engraving represents the irregular line of union of the bones of the scull, as seen on the outer surface.

and, as it were, buried in the head; but the jaws, instead of being spongy bones, as in man, are dense and strong to sustain the teeth; for what would avail these teeth, long, and sharp, and strong, could they be twisted from their socket? and what would avail the strength of the jaws, and length and depth of the teeth, were not the proper scull surrounded with spines and arches of bone dense and strong enough to give attachment to the muscles of the jaws? Thus, in the carnivorous animal, the strength of the bony textures of the head is all concentrated in the jaws of the animal, and corresponds with its instinct to hold and rend its prey.

But when the lion or the tiger have struck down their prey, and have gorged themselves and sought their dens, and when the lesser carnivorous animals have cleared the bones, there remains a rich repast which they cannot reach; then comes the hyæna, which cracks the bones and feeds upon the marrow.

Of all the sculls that can be collected in a museum, the jaws and teeth of the hyæna exhibit the most extraordinary strength; the bones having a clumsy form and dense texture quite peculiar, and suited for the socketing of the strong conical teeth.

We see, therefore, that the fabric of the head, taken as a whole, bears a certain resemblance in all classes of animals; but, though built upon the same general plan, the supports are given to fortify the points which bear the shock.

By such more obvious instances of adaptation we are led to inquire whether any similar adjustment of the resisting property of the bone is to be found in the human head. We must carry this along with us in our inquiry, that a shock or vibration going through the great mass of the human brain proves more immediately destructive of the faculties than the wound which penetrates the substance without a concussion. When we contemplate the condition of a child, its fearlessness, its restless activity, the falls and knocks it gets, we must perceive that, were not the textures of the bones and the brain adjusted, the child when it fell must have lain insensible, instead of rising and crying more from terror than the sense of injury.

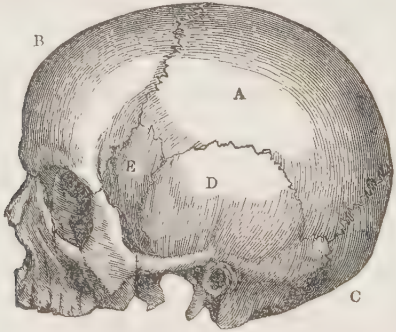
We may contrast this condition of the child with that of an old man losing his balance and falling on his head, who lies insensible from the shock. Is it not apparent that there is here a calculation of the accidents of life, and a provision against them, which yet leaves us threatened with danger, and, therefore, on our guard?

The difference in the textures of youth and age are instructive as to the causes of the diversity. The brain of the old man is firm; the vibration injures its fibre. The brain of the child is soft, and in infancy it may be moulded to any shape. Then, again, the texture of the bone is entirely different, and hardly like the same substance. It is thin and pliant in the child, actually dimpled by a blow; while in age it is brittle from its density, and the vibration of the blow runs round it; or, if it be broken, it is like a piece of sharp glass entering the tender parts beneath.

Much more than will stand inquiry has been said of the forms of the head in reference to the contained organs; but there is a simple demonstration which should precede all this; the forms of the scull bear a relation to pressure and injury from without, and the parts most exposed are most protected. A man falling backward has the back of his head exposed to injury, and the examination and section of the bone at this part shows how nature has strengthened it by

giving it greater thickness and prominence, and by groining it within. We say groining it, for there is nothing more resembling the strong groinings or arches of the ground story of a great building than the ridges of the scull at this part of its base, which cross at a centre corresponding with the prominence of the occiput.

In front, the form of the scull exhibits a provision not less distinct in its object. The parts of the forehead which are most prominent and exposed (*eminentiæ frontales*) exhibit, on their section, a thicker and denser bone; while the lower part of the forehead is formed of cells or sinuses, which, throwing off the outer wall of the scull from the surface of the brain, still more effectually protects it.

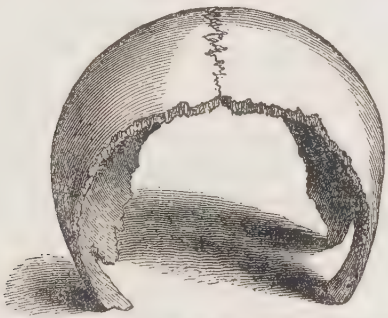


A. The *parietal* bone. B. The *frontal* bone. C. The *occipital* bone. D. The *temporal* bone. E. The *sphenoid* bone.

A person tumbling sideways pitches on the shoulder, and the convexity of the head comes to the ground precisely on that point (the centre of the parietal bone) where the bone is thickest and most dense.

It is, on the whole, impossible to study the forms of the head without acknowledging that the shape, thickness, and texture of the scull have reference to the liability to pressure and blows from without.

To take a farther example: It seems very natural, in carrying a burden, to poise it on the head. Now, whether we take the carpentry (called a *centring*) on which the stones of the arch of a bridge are laid in building it, or the arch of stone, or a dome (for with all these the bones of the head may be aptly compared), there has been nothing ever contrived so perfect as the joining of the bones of the head to resist both pressure above and straining at the sides. And if, on this subject, we solicit the reader's attention more particularly to these joinings, it is because, in books merely anatomical, they are apt to be treated like things of accident, and described as the running of the fibres of one bone into another, the necessary consequence of their mode of growth, or the accidental effect of the pressure of the muscle; whereas, on the contrary, the finest tools of the carpenter could make nothing so perfect or so demonstrative of design.*



The figure represents the two parietal bones, forming an arch or a surmounted dome.

* This subject is pursued in more detail in an Essay published by the Society for the Diffusion of Useful Knowledge, under the title of "Animal Mechanics." It is there shown that the bony substance of the scull separates, in the maturity of man, into two plates or tables, and of different degrees of hardness, with an intermediate soft substance; and that, by this arrangement of sub-

These provisions would surely have met with earlier attention had men contemplated in a true view the object of the animal framework, which is not to give absolute safety against inordinate violence, but to balance the chances of life, leaving us still under the conviction that pain and injury follow violence; so that our experience of the injury, and our fear of pain, while they are the principal protection to life, lay the foundation of important moral qualities in our nature.

IV.

THE FORMATION AND GROWTH OF TEETH.

Seeing how admirably these instruments have been adapted to their several uses, the reader must be curious to know how they are produced, how they are manufactured with so fine a "prospective contrivance." Three different substances are exposed on making the section of a tooth, viz., ivory, or the bone of the tooth; the enamel, which is very hard, and breaks with a vitreous fracture; and a substance differing in some respects from both, and which English anatomists have called crusta petrosa, and Cuvier cement. These three substances are not formed in every tooth. Some teeth consist entirely of the bone or ivory, as those of the porpoise and bottle-nosed whale. In man and in the carnivorous animals, the bone is covered with enamel, and in the graminivorous and ruminant animals all three substances are found.

In the chapter on bone, it has been shown that its texture must be loose to admit bloodvessels; for bone is nourished and undergoes changes through the in-

stances of different densities, a shell or covering is given for the protection of the brain, opposing sufficient resistance to pressure, and, at the same time, calculated to stifle vibration from a blow.

fluence of the circulating blood in it. But the almost stony density of the teeth does not admit of circulation within them; yet they possess life, and through that principle are in union with the gum and jaw. A dead tooth, however pure and perfect when thrust into the socket of the jaw, remains there no longer than would a peg of wood or of metal. It causes inflammation and pain, and is thrown out.

It would be a difficult question for those who consider life to be the result of organization, to solve how a principle of life should exist for a term of years, giving rise to a sympathy and union with the jaw, in a part like the bone of a tooth, which has neither what they call organization nor any circulation of blood in it. Here we have one of those inscrutable qualities of life which makes physiology a science distinct from all others; and it is an example of there being adaptations far more admirable than merely mechanical appliances.

But we were about to show how the different portions of a tooth are formed. In the jaw of the young animal a sac is discovered, which contains the rudiments of the tooth. On opening the sac, we think we see the tooth, but it is only a body of the form of the crown of the tooth, and is soft to the touch. This is called the *pulp* of the tooth; although pale at first, at a stated period it becomes full of blood, and then the bone of the tooth begins to be formed; and now, on touching it, we can lift from it a delicate shell, which is at once of the form of the pulp and of the perfect tooth. The process thus begun is completed by the secretion of successive strata from the surface of the pulp, until the bone of the tooth, which was at first a mere scale, becomes a dense body, with a small cavity and tube leading to it; and the pulp, which was of the size and shape of the tooth, shrinks to a mere shred, containing a nerve and vessels.

Thus the original use of the pulp is changed: but it remains, serving an important purpose; for, by sustaining a sensible nerve within the tooth, it extends a degree of protection to it. The teeth are sensible to

what we masticate; they are sensible to the smallest particle of sand, and so are they to the degrees of heat. This sensibility is necessary to their protection and to the continuance of their vitality, yet the sensibility is not in the substance of the tooth, but in the nerve within; and the density of texture of the tooth becomes a medium through which both mechanical vibration and heat are readily communicated to the nerve.

We have seen how the bone of the tooth is secreted by the pulp. The enamel is formed differently. The sac, which covers the whole pulp and rudiments of the tooth, has a fine organization, as displayed by the art of the anatomist, and its inner surface throws out a fluid, which, falling on the surface of the bone of the tooth (already formed by the pulp), there concretes or undergoes a species of crystallization, and hardens into enamel.

The difference between the bone and enamel of a tooth, that is, between what is formed by the pulp and by the sac, is shown by a very simple process. When a tooth is immersed in diluted nitric or in muriatic acid, the enamel is dissolved with effervescence, and is completely carried away; but when the earth of the bony part is dissolved, it leaves behind it a cartilaginous matter, which constituted a part of the bone of the tooth. In its chymical composition the bone of the tooth resembles the bone of the skeleton, though not strictly and anatomically, as it wants the vascularity of true bone; it is, therefore, with more propriety called ivory.

We have still to explain how the compound teeth of the vegetable feeders are formed. Now if we comprehend the means employed in the simple tooth, we shall have little difficulty in understanding this. The pulp is divided, and consists of parallel layers joined below, but free above, and with considerable interstices. These divisions or processes of the pulp secrete the ivory upon their surfaces, by which, of course, plates of this dense material are formed on each side of the soft processes or tongues of the pulp.

There will, therefore, be double the number of plates of bone that there are processes of the pulp.

Each plate of bone must be covered or invested with enamel. This is effected by folds or projecting processes of the capsule or sac, which, hanging from above, intervene between the plates of bone, and there perform their peculiar secretion, depositing the enamel. But it would appear that these processes, becoming at length tightly embraced by the plates of enamel which they have themselves secreted, throw out a less perfect material, as it were; this is called the *crusta petrosa*, or cement. When the tooth thus formed rises above the gum, and when attrition wears down a part of it, the interstices caused by the wasted processes of the septa of the sac are exposed, and the food is crammed down into these crevices; and then, on making a section of the tooth, we may discover four substances, ivory, enamel, crusta petrosa, and foreign matter, in alternate layers.

Now, contemplating the slow formation of the teeth while yet deep in the jaw; their curious mode of growth, adapted to the form of the jaw; the articulation of the jaw with the head; the position and powers of the muscles that are to move the jaw, with the means to be employed by the animal in gathering, masticating, and digesting its food, we can desire no more absolute proof of prospective contrivance and design. Were we to seek farther, we have only to compare these mechanical appliances with the instincts and propensities of the animals.

There is but one thing more worthy of attention in the teeth than their mechanism, we mean their vital properties. Is it not a wonderful thing to see the jaw of the infant with a ridge upon its gums, harmless to the nipple; and then, at the time when the powers of digestion vary, and become suited for stronger food, to find sharp teeth arise, a range of them having been provided, which, when fully developed, are in exact accordance with the size and form of the jaw of the child? Can any one tell us how these teeth should waste at an appointed time, to give place to others of

stronger form and of larger dimensions conforming to the adult jaw-bone? The phosphate, carbonate, and fluate of lime do not differ in these milk teeth or deciduous teeth, and in the adult teeth; yet, by a secret process of decay, the first fall out in the period of childhood, and the second last a long lifetime.

V.

OF THE MOUTH.

Our author has said that everything in the structure of the mouth is mechanical, and he has given a very attractive view of the varieties of the mechanism in the mouths and bills of animals. But, so far from exhausting the subject, he has left some of the most interesting particulars untouched. In man the mouth is not flat because he has hands, but because it is a part of that apparatus which is the most curious and important of all the bodily structures, the instrument of speech. In that light we shall presently take it up separately, not doubting that it will reward the reader's attention.

Let us, in the mean time, consider some of the common properties of the mouth; and, first, of the most obvious parts, the lips. Nothing serves better to make us appreciate the blessing we enjoy than examining the organization of a part which, from its familiarity and the absolute perfection of its action, we neglect or think meanly of. The lips receive the food and aid in mastication; they are a principal part of the organ of speech; they are expressive of emotion; they are the most acutely sensible to touch. But all this never moves our surprise or admiration.

If we know anything of muscularity, we must presume that there is a concourse of fine muscles converging to the lips and surrounding them. But what

gives the lips their sensibility? This was a question early suggested to me in my investigations on the nerves; when experiment showed that one nerve went to the lips for sensation, and another for motion. The vermilion surfaces of the lips possess their exquisite sensibility through minute and delicate villi, into which the extremities of the sensitive nerve are distributed: and these, being covered only by a cuticle the most thin and transparent, afford the ready instrument of touch. We see how the child uses the lips, as giving him his first information of the qualities of bodies.

It is certainly an unexpected thing to find that two organizations totally distinct, combined in the lips, should be necessary to the simplest act. If the nerve of motion be cut and has lost its function, the animal puts its lips to the grains it feeds upon, but cannot gather them. If the nerve of sensation be injured, the animal presses its lips to the food, but wants the sensibility by which the motions of the lips should be directed. These facts show that, while sensibility and motion are distinct faculties and depend upon different nerves, they are necessarily combined for so simple an act as taking the food into the mouth. We thus daily see that in paralysis, sometimes one property is lost, sometimes another; a circumstance most important to the physician.

As connected with our present subject, it is a strange thing to see that, while a person may have every capacity for motion in the lips and tongue, he will have the morsel remaining in the mouth without knowing it. The first instance I found of a defect in the lips exactly similar to that produced by cutting the nerve of sensation on one side of the face, was in a gentleman who, being under the hands of his dentist, had the nerve of sensation hurt by the pulling of a tooth: and, having a glass of water given to him, remarked that the glass was a broken one: the fact being, that the portion of the tumbler in contact with one half of his lips was not felt at all, which gave him the same sensation as if a bit of the glass had been broken away.

We might show, in the lower creatures, an infinite variety in the forms of the mouth; but even in the mammalia we may perceive that the lips are projected, and have a power almost like that of the hand. The horse has great power in his lips. The camel, the elk, but more especially the rhinoceros, have a still greater mobility, and the latter has a very fine sensibility in the hook-shaped extension of its upper lip: the snout of the tapir and the trunk of the elephant belong to the lips rather than to the nostrils. We have the least equivocal proof of this in their supply of nerves; which are only an enlargement or prolongation of those nerves which in man go to the lips. Nay, we may state a fact, perhaps unexpected to the reader, that the whiskers of animals of the cat tribe have entering into their roots branches of the same nerve which gives sensibility to the lips; and the palpa and tentacula in the lower classes of animals, as the crustacea and insects, however different these organs may appear, are known to belong to this order of parts, by the same proofs, their supply of nerves.

We might be tempted here to speak of the bills of birds, had they not already attracted the attention of our author. We shall, therefore, rather fortify his conclusions by attention to the structure of the tongue. The human tongue is, no doubt, the most admirable of all the organs. We might have very obvious proofs of intention and adaptation in the long rough tongue of the ox, or in the still more curious and active tongue of the camelopard, or in the tongue of the insectivorous animals, the bear, the chameleon, and anteater, or in the variety of curious instruments, darts or saws, sheathed in the bills of insectivorous birds. But we ourselves have an organ, however apparently simple, finer than all these. The human tongue, containing muscular fibres in every possible direction, and round, soft, and mobile, is less admirable as an organ of mastication, of taste, or touch, than as the organ of speech, modulating with every possible variety the sounds issuing from the windpipe. On

the upper surface of what is termed the dorsum of the tongue, there are rough papillæ, which in some measure correspond with what we see in animals: they are subservient to the taste. Some of them have a mushroom-like top, and a stalk projecting from the bottom of a little hollow, and there the sapid particles of the food lodge, and prolong the enjoyment of the palate. But in the organization of the tongue there is one minute point of structure more curious than all the rest. When the papillæ are examined with a magnifying-glass, there are seen certain small bodies, consisting of a gray sheath, within which there is a little red point; and this point is capable of erection, thus projecting and becoming the organ of taste. It is so erected when the morsel is in the mouth, or when we are in the immediate anticipation of food. There are other more minute processes studding the surface of the tongue, and these contain the extremities of nerves which are sensible to touch. It must surely, therefore, be considered an admirable thing to find so many faculties seated here, each with its appropriate organization, and each most curiously connected with other structures; that we should have the power of mastication, of deglutition, of modulation of the voice, the senses of taste and of touch, concentrated in one apparently simple organ.

Not to speak of other relations, can there be any better proof of design than the effects of the excited sensibility of the tongue? No sooner have these gustatory points of nerves been excited, than there is poured out into the mouth most abundantly, by four distinct tubes, the saliva, that fluid* which facilitates mastication, and directly prepares the food for the action of the stomach. And however well we might

* We presume that the fluid is chiefly useful in mastication, as the glands are large, and the fluid most abundant in animals that chew the cud. In all, these glands are so disposed as to receive gentle pressure from the motion of the jaw; so that, while their vascular apparatus is excited by the sensibilities of the tongue, the fluid is urged from the ducts by the pressure of the jaw and muscles which move it. The fluid itself is neither acid nor alkaline.

imagine such a supply of fluid to assist deglutition, this is not all that is here done in preparation; for while the morsel is moved by tongue, and lips, and jaws, an appropriate fluid is collecting in what appear to be mere irregularities in the back part of the throat, but which are, in truth, so many receptacles that, pointing towards the stomach, give out their contents as the morsel passes.

There is one curious circumstance which we may notice before quitting this subject. Eating seems always to be an act of the will, and attended with gratification. It is well known that the operation, or what is very nearly the same, may go on within the stomach, without any outward sign, at least, of pleasure. The gizzard (with which we are most familiar in fowls, though it be, in fact, found in the vegetable feeders of the different classes of animals) is correctly enough described as an organ of mastication, in which there is an incessant and alternate action of opponent muscles, as in the motions of the jaws. In the stomach of the lobster we have not merely the muscles of mastication, but the teeth also: so that it appears the function may be performed altogether internally, and without the volition, and, probably, without the sensations that accompany the offices of the mouth. We mention this as drawing the reader to comprehend that many organs may be in operation in the internal economy without our consciousness.

Our author, with much propriety, from time to time adverts to those changes in the organization which accommodate the animal to new conditions. Now, in terrestrial animals, the act of swallowing must be accommodated to the atmosphere; but if the animal lives in water and still breathes the air, the structure of the parts must be changed. The crocodile seizes its prey, and descends into the water with it. Its power of descending does not, as in the fish, result from compressing the air-bladder: but is owing, as

we have shown, to a provision in its ribs and lungs. Unless the crocodile could expel the air from its lungs in a greater degree than the mammalia are capable of doing, it could not crawl upon the bottom, nor retain its place there without continual exertion. There is an adaptation to this mode of destroying its prey, by carrying it under water, in the mouth, as well as in the thorax and lungs. The crocodile has no lips; it lies on the shore basking with its mouth open, and flies light upon and crawl into its mouth. Against these the air tubes are protected, not by the lips and sensibility of the mouth, but by an apparatus which separates the mouth from the throat and windpipe. This partition between the cavities is necessary when the animal seizes its prey: for as it plunges under the water with open mouth, the air tube must be protected against the ingress of the water. For this purpose there is a transverse ridge, arising from the body of the bone of the tongue, which raises a duplicature of the membrane so as to form a septum across the back part of the mouth; while the curtain of the soft palate hanging from above meets the margin of the lower septum, and they form together a complete partition between the anterior and posterior cavities. Thus the animal is enabled to hold its prey in the open mouth, without admitting the water to the air passages.

With these observations, we hope the reader will return to peruse, with increased interest, the conclusions so well stated by our author, vol. i., p. 180.

VI.

OF HUNGER AND THIRST.

For very sufficient reasons, we have preferred taking the illustrations of design from the mechanical structure of the body. We may now introduce some instances from the living properties, the propensities and appetites.

Hunger and thirst are in truth senses, although the seat or organ is not easily ascertained. The wants, and desires, and pain accompanying them resemble no other sensations. Like the senses, they are given us as monitors and safeguards, at the same time that, like them, they are sources of gratification.

Hunger is defined to be a peculiar sensation, experienced in the stomach from a deficiency of food. Such a definition does not greatly differ from the notions of those who referred the sense of hunger to the mechanical action of the surfaces of the stomach upon each other, or to a threatening of chymical action of the gastric juice on the stomach itself. But an empty stomach does not cause hunger. On the contrary, the time when the meal has passed the stomach is the best suited for exercise, and when there is the greatest alacrity of spirits. The beast of prey feeds at long intervals; the snake and other cold-blooded animals take food after intervals of days or weeks. A horse, on the contrary, is always feeding. His stomach, at most, contains about four gallons; yet throw before him a truss of tares or lucerne, and he will eat continually. The emptying of the stomach cannot therefore be the cause of hunger.

The natural appetite is a sensation related to the general condition of the system, and not simply referable to the state of the stomach; neither to its action, nor its emptiness, nor the acidity of its contents; nor in a starved creature will a full stomach satisfy

the desire of food. Under the same impulse which makes us swallow, the ruminating animal draws the morsel from its own stomach.

Hunger is well illustrated by thirst. Suppose we take the definition of thirst: that it is a sense of dryness and constriction in the back part of the mouth and fauces; the moistening of these parts will not allay thirst after much fatigue or during fever. In making a long speech, if a man's mouth is parched, and the dryness is merely from speaking, it will be relieved by moistening; but if it comes from the feverish anxiety and excitement attending a public exhibition, his thirst will not be so removed. The question, as it regards thirst, was brought to a demonstration by the following circumstance: A man having a wound low down in his throat was tortured with thirst; but no quantity of fluid passing through his mouth and gullet, and escaping by the wound, was found in any degree to quench his thirst.

Thirst, then, like hunger, has relation to the general condition of the animal system, to the necessity for fluid in the circulation. For this reason, a man dying from loss of blood suffers under intolerable thirst. In both thirst and hunger, the supply is obtained through the gratification of an appetite; and as to these appetites, it will be acknowledged that the pleasures resulting from them far exceed the pains. They gently solicit for the wants of the body: they are the perpetual motive and spring to action.

Breathing, as we have seen, is even more directly necessary to life than food; but to this we are differently admonished. An appetite implies intervals of satiety and indifference. The uninterrupted action of breathing could not be supported by a perpetual desire; we cannot imagine such a uniformity of sensation. The action of breathing has been made instinctive, while pain and the alarm of death are brought as the only adequate agents to control the irregularities of a function so necessary to life. Pain does here what desire and the solicitation of pleasure could not accomplish.

VII.

MICROSCOPIC PHENOMENA IN THE ANIMAL BODY—MOLECULAR MOTIONS—CILIARY MOTIONS.

We have noted the judicious course pursued by Dr. Paley in preferring the proofs of design drawn from the structures of our bodies, which secure our existence, or minister to our comforts or enjoyments; for in these there may well be perceived the object of the provisions, and the mode by which they are attained; and this supports us in a due estimate of ourselves, seeing that there is so much care of us, and that our bodily and intellectual endowments have so many relations to the system of nature. By the aid of the telescope or microscope we are equally carried, as it were, out of ourselves, to view nature foreign to us. If, it has been justly observed, in contemplating the heavens with minds ill-confirmed as to the intentions of Providence towards us, the study is far from being consolatory, the same may be said of the microscopic world. The discovery of the universal prevalence of life, of animals within animals, of the inhabitants of a drop of fluid as difficult to enumerate or arrange as those of the ocean, gives rise to thoughts which do not flatter our self-importance more than the contemplation of the magnitude of the heavenly bodies, and the extent of space through which they range. It will, therefore, be tending to the object of this volume to show that, with the microscope, that is, by observing the atoms of our frame which are invisible to the naked eye, we discover motions and actions, both of inorganic and animated particles, which tend to the preservation of life, and to the performance of the offices in the animal economy fully as remarkable as the contractions of the heart or the play of the lungs.

It will be necessary to the correct estimate of the facts which we have to mention, that we advert to a

curious discovery of Mr. Brown relative to the motions of inorganic molecules. This gentleman's celebrity is of a kind which may not readily be comprehended by some readers; for his retired and philosophical habits cause him to occupy a small space in society at home, in comparison with that reputation which extends wherever science is cultivated. He was directed to this subject by a motion visible in the pollen of plants when under his microscope, which led him to farther investigations; and he found that when inorganic as well as organic bodies were minutely divided, and floated in a drop of water, active motions were seen in the molecules. The motions of these particles are different from those of animated matter. The molecules are spherical, and between 1-20,000th and 1-30,000th of an inch in diameter. I have myself seen these, and nothing can be more surprising than their evolutions, like figures in a dance, apparently produced by the attraction and repulsion of the particles themselves. It might be supposed that the rapid evaporation from the surface of the drop would produce eddies within it, and that these molecules were carried by the circulation of the fluid; but the ingenious mode by which Mr. Brown prevented the evaporation of the watery particle, by surrounding it with oil, while the motions of the molecules continued, refutes this hypothesis, and inclines us the more to rejoice that the curious phenomenon was discovered, not accidentally, but by a philosopher.

Indeed, while looking upon these molecules, we are surprised by bodies, obviously animalcules, jostling them, and darting across the field of the microscope; and the natural reflection is, how much more minute must the constituent parts or molecules of these animalcules be! Their motions are not fortuitous, or owing to any polarization or influence external to them, as galvanism or magnetism: they have instincts and appetites, and are susceptible of excitement: their bodies are nourished by digestion or imbibition: they have circulation, though it may be with

a different apparatus from that of larger animals: their circulating fluids, their containing vessels, their apparatus for motion, imply that the ultimate molecules of their composition must be infinitely small, even in comparison with the minute particles which we are contemplating; and this we state, to do away with those speculations which men are prone to indulge in when they suppose that they have at last attained a sight in these active molecules of the ultimate particles which constitute the framework of animals.*

Another class of facts drawn from the minute world is no less wonderful than the motion of those "active molecules:" we allude to certain vibratory motions, or, as they are termed, *ciliary* motions, on the mucous surfaces of animals. They are somewhat analogous to the actions of the rotatory apparatus of some of the infusoria. Both the respiration and the prehension of food in these animals are accomplished by an influence of their bodies, whereby a current is kept up in the surrounding fluid; a fresh stream by this means plays over the apparatus of their respiratory organs, while in some the minute particles of nutritious matter in the fluid are brought in contact with their prehensile organs.

The soft aquatic animals, called porifera, have many orifices on their surface, into which the surrounding fluid is drawn, and, being then brought into a common sac, it is expelled through a larger central mouth.† We can conceive an action of these pores, by which the water may be sucked in and propelled; but the more curious action is that of the cilia or filaments with which their tentacula are covered. These cilia have a motion which produces a vortex in the fluid, and tends to convey the floating nourishment towards the mouth.‡

This well-attested fact leads us to comprehend the

* Animalcules are visible in the microscope, so minute, that it is estimated that a million of them do not exceed in magnitude a grain of sand.

† Dr. Grant. ‡ Spallanzani.

phenomenon which is the principal object of this note, and explains what is meant by "ciliary motions." It is here necessary to mention that what anatomists term the mucous membrane is the lining of all those tubes and cavities of the animal body which open outwardly, in contradistinction to the membranes which line the proper cavities of the body, and which are called serous membranes. It is of itself a circumstance tending to the support of the conclusions to which the whole arguments of this book point, that the fluids thrown out to lubricate these surfaces are various and appropriate to the nature of the cavity. The membrane, which is continuous all around, and has no outlet, must be moistened by a fluid which is to be absorbed again; but the surface of the cavity, which has an outlet, is moistened by a fluid which is to be discharged as from an emunctuory.

This brings us to the fact above referred to, which, if the observation has been correctly made, is by much the most extraordinary in the whole animal economy.* A portion of the mucous membrane of an animal recently killed is placed, with great nicety, under the field of the microscope, and in water: some fine particles, which will float in the water, are then added. What has been used with most advantage is the black pigment of the eye, which is easily diffused, and the particles of which are very minute. The experimenter is here cautioned to distinguish the molecular motions discovered by Mr. Brown from those now to be described. A rapid vibratory motion is to be seen on the surface of the membrane, and these motions produce a current in the fluid in contact, which is made apparent by the floating of the minute particles of the pigment. The remarkable part of this phenomenon is the direction of these currents. The cilia, or small filaments projecting from the membrane, move in such a manner that the current is always directed towards the outlet of the cavity or tube; and thus it is conjectured that a new source and kind of action, inde-

* First observed by Purkinje and Valentin.

pendent of muscularity (that is, the irritability of the grosser muscular fibre), is provided for the gradual and regular ejection of the secretions from these tubes and cavities, which enter deep into the animal structure. In this country these extraordinary endowments of the living surface are under the examination of one* who will prosecute the subject with philosophical precision, and the result of whose inquiries may be expected with an interest proportioned to the important nature of the facts.

VIII.

ON LIFE.

When we survey the discoveries in the physical and abstract sciences, our wonder and admiration are excited by the great and various powers of the human mind; but we learn, also, that men acquire a habit of viewing objects and of thinking, which trammels them, though possessed of the highest genius, when they change abruptly the subject of their studies.

The life of the body is a study new to science, and it has no natural alliance with any of the higher branches which occupy men of intellect; yet it requires a great reach of thought. Those who follow intricate mathematical deductions, calculate the return of comets, estimate the magnitude and attraction of the sun and planets, and even extend their investigations to the fixed stars, come to the subject as much under the influence of habit as the artisan who tries to accomplish by the dexterity of his hand that for which a different manner of working has unfitted him. This may be a humiliating consideration, yet it must be acknowledged, or we shall never dis-

* Dr. Sharpey, of Edinburgh.

cover by what hypotheses we have hitherto been misled; nor can we be directed in a course of observation likely to advance the science of Life.

The chymist is in the habit of observing the laws of invisible powers, of electric attraction, of heat, and of electrical, or galvanic, or magnetic influences. He makes a step, from the observation of the mere ponderable and visible qualities of matter, to the study of laws which govern that which can neither be weighed nor confined; and we should imagine, therefore, that the process of his reasoning would prepare him for comprehending more easily the influence of life, as exhibited in the phenomena of the animal body. But it has been far otherwise. The chymist, when he commences the study of physiology, instead of pausing and considering that he is about to enter on a new region, where phenomena unexampled before are to be presented to him, or are to be seen through different media, and the forces estimated by different means, carries along with him habits of thinking which promise no improvement in this new field; and, coming encumbered with all his apparatus, proceeds to measure that property which gives sensibility, motion, and thought, by the instruments he has hitherto employed in marking the current and force of electricity; and regards the brain as no more than an electric pile discharging at intervals along the nerves the fluid successively developed. Such are the false analogies which satisfy ingenious minds, so that they cease from inquiry, and leave science stationary. The mathematical and mechanical physicians long retarded the true knowledge of physiology; and we are now nearly as much embarrassed by the fashion of the day, of applying, to investigate the laws of life, the mode of reasoning which has been successful in the chymical sciences. There are but two men who have enlightened us on the doctrine of the life of the body, Haller and Hunter; and this is, in other words, saying that it is altogether a recent science.

It is necessary to premise thus much, that the reader may not feel disappointment if he fail at first in

attempting to comprehend the subject. What does he understand by life? That intelligence, feeling, and motion which he sees manifested in the animal body. If, in this understanding of the term, he hears that Mr. Hunter discovered that there was life in the blood, it is possible that he may receive the announcement with the same ridicule with which the world at first heard it. But let us see how the subject opened upon Mr. Hunter's mind. He was engaged in minute inquiries into the gradual development of the chicken in the egg. On breaking one egg it was found perfectly sweet; the next was in a high state of putrescence. What, then, was the difference of their condition? Now let us not confound this question with what is termed organization. The chick at this time is concealed within a vesicle not larger than the head of a pin. It is the white and yolk of the egg that we are examining. Here is no heart, or vessels, or brain, or nerves, or anything of an animal body. The question of organization, then, is put quite aside. Nevertheless, Mr. Hunter conceived that the difference between the putrid and the sweet egg depended upon the influence of life, which in the latter counteracted the chymical affinities, and prevented the matter from falling into a putrescent state. If, then, said he, the matter of the egg has that property of life to check and control the affinities which all matter divested of life is subject to, has it also the power of resisting the changes of temperature? And now, upon comparing the putrid and the living egg, he found that the latter resisted freezing; and he thus showed that the property which resists putrefaction is allied to the property of the animal body which preserves in it a uniform heat, though exposed to the changes of temperature in surrounding bodies. We see by this that a portion of matter in an egg or in a seed, shall be endowed with a principle which, however obscure, we perceive by its effects.

Thus living matter is under the influence of laws totally distinct from those which govern dead matter. What shall we call this peculiar property? We have

acquired a notion of life by witnessing the effects of many causes combined in the whole animal. Motion is in general the result of these; and so we associate life and motion. Mr. Hunter showed that each part of the body which possessed life exhibited it by different phenomena. He said truly, that when the muscle cut off from the animal recently killed still palpitated, it was by its property of life. Accordingly, when a portion of the blood was withdrawn, he observed that it exhibited properties totally different from dead matter: it was drawn a fluid; and this fluid presently coagulated. What, said his opponents, is there in this? Do we not see a fluid jellying and becoming solid; and is this to be a proof of life? But Mr. Hunter demonstrated that the coagulation of the blood was not in any respect like the formation of a jelly; that heat neither accelerated nor prevented it; that it took place whether the fluid was left quiet or stirred; that nothing prevented the blood becoming solid but the contact and influence of the living vessels of the body. He showed, also, that the blood could be deprived of life or killed, and then it no longer coagulated. In short, he compared this property of coagulation in the blood to the contraction of the muscle; and, among other remarkable properties in the blood, he pointed out the coincidence, that, when a man was killed by lightning, the muscle did not stiffen in death, that is, it did not contract, neither did the blood coagulate.

The next step of Mr. Hunter was to combat those who would represent the body as bearing a resemblance to machinery moved by a weight. In the machine, he said, the weight of the jackstone is conveyed from one lever to another, and from one wheel to another; but what is there in this analogous to motions of the living body? Take away one of these wheels or levers, there is no property or power in it; take a part of the body, and it has life, not as a property common to all the body, like that of gravitation in dead matter, but each portion has that endowment of life which is demonstrable or evident by

distinct phenomena: and then he adds, true it is that there is the example of beautiful machinery in the animal body; but how much more admirable are the different endowments of life which, corresponding together, minister to the intellectual being! One part has the property of receiving impression, another has the property of transmitting it, though it could not receive it. The mind, thus approached and influenced, gives out its mandate by cords totally distinct, and with different properties; these have no motion in themselves, but they arrange and control the moving organs of the body, which give locomotion and agency. The whole body, then, is a collection of parts, possessing different endowments of life, exhibiting, by different phenomena, the presence of that life, and these different endowments have a bearing to each other, or a systematic arrangement, by which the communication is established between the mind and the external and material world.

Mr. Hunter illustrated the subject thus: Death is apparent or real. A man dragged out of the water, and to appearance dead, is, notwithstanding, alive, according to the definition we have given. The living endowments of the individual parts are not exhausted. The sensibility may be yet roused; the nerves which convey the impression may yet so far retain their property that other motor nerves may be influenced through them; the muscles may be once more concatenated, and drawn into a simultaneous action. That vibratory motion which we have just said may be witnessed in a muscle recently cut out of the body, may be so excited in a class of muscles—for example, in the muscles of inspiration—that the apparently dead draws an inspiration. Here is the first of a series of vital motions which excites the others, and the heart beats, and the blood circulates, and the sensibilities are restored, and the mind, which was in the condition of one asleep, is roused into activity and volition, and all the common phenomena of life are resuscitated. Such is the series of phenomena which is presented in apparent death from suffoca-

tion; but if the death has been from an injury of some vital part, the sensibilities and properties of action in the rest of the body, though resident for a time, have lost their relations, and there is a link wanting in that chain of vital actions which restores animation. Here, then, there can be no resuscitation; and the death of the individual parts of the body rapidly succeeds the apparent death of the body.

We perceive now that our original conception of life, and the terms we use respecting it, in common parlance, are but ill adapted to this subject when philosophically considered. We early associate life and motion so intimately that the one stands for the other. If we then investigate by anatomy, we find a curious and minute mechanism in operation, an engine and tube for circulation, and, in short, an internal motion of every particle of the frame; and the anatomist is also led into the error of associating in his mind life with motion and organization. But when we consider the subject more closely, and divest ourselves of habits and prejudices associated with words, we perceive that, without making any vain and even dangerous attempts at definition, life is first to be contemplated as the peculiarly distinguishing one of two classes into which all matter must be arranged: the one class, which embraces all living matter, is subject to a controlling influence which resists the chymical agents, and produces a series of revolutions in an order and at periods prescribed; the other, dead matter, is subject to lapse and change under chymical agency and the common laws of matter.

Let us examine the body of a perfect or a complicated animal. We find each organ possessed of a different power. But there is, as yet, no conventional language adapted to our discourse on this subject, and that is the source of many mistakes; for when a man, even like Mr. Hunter, had his mind illuminated upon this science, how was he to frame his language, when every word that he used had already a

meaning which had no reference to the discovery he had made, to the distinct qualities which he had ascertained to belong to the living parts?

The progress of science in the present day, although it does not bring us nearer to the comprehension of the nature of life, yet furnishes us with such analogies as enable us more easily to comprehend how this principle may be combined with the material of an animal body, and yet be perfectly distinct from it. The discoveries which have led to the atomic theory, and to that of the molecules of bodies being under a polaric influence, leave us with the impression that the minute particles of common matter (in contradistinction to living matter) are under an influence which may be bestowed or withdrawn: that as the index of the compass points to the north by no property of the metal itself, but through an influence given to it and existing around it, so do the most minute particles of bodies arrange themselves by some such superadded influence, and partake of polarization. If, then, according to the prevailing opinion of philosophers, everything we touch, or see, or taste, all matter, in short, exhibits qualities arising from the arrangement of particles infinitely minute, and that arrangement resulting from an influence exterior to them, or superadded to them, does it not facilitate our conception of a power or property bestowed on what is termed living matter, and yet essentially distinct? The difference between dead and living matter will then appear to be, that in the one instance the particles are permanently arranged, and continue to exhibit their proper character, as we term it, until, by ingenuity and practice, some means are found to withdraw the arranging or uniting influence, and then the matter is chymically dissolved: resolves into its elements, and forms new combinations: while the life continues, not simply to arrange the particles, and to give them the order or organization of the animal body, but to whirl them in a series of revolutions, during all which the material is passive, the law being in the life. The order and succession of these changes

and their duration do not result from the material of the frame, which is the same in all animals, but from that influence which we term life, and which is superadded to the material.

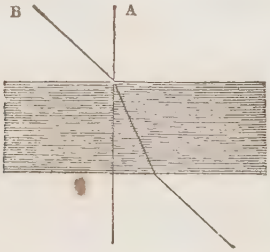
IX.

ON THE RAYS OF LIGHT, THEIR REFRACTION AND REFLECTION.

The nature of light has ever been a subject of controversy. It was Newton's explanation that luminous objects give out particles of inconceivable minuteness, and moving with extreme velocity. "What mere assertion," says Sir John Herschel, "will make any man believe that, in one second of time, in one beat of the pendulum of the clock, a ray of light travels over 192,000 miles, and would therefore perform the tour of the world in less time than a swift runner would make one stride?" In short, there is nothing like it but the influence of attraction, which is so instantaneous as to admit of no calculation of time at all.

A different theory from that of Newton was suggested by Huygens, who supposed a highly elastic fluid to fill all space, and which, when moved, produced the effects ascribed to light. Instead of minute particles diverging from the luminous body, he substituted waves or vibrations, propagated through this elastic ether. The late Dr. Young, and some continental philosophers more recently, took up this hypothesis, and supported it by ingenious experiments. But, notwithstanding that it is the favourite theory of the day, difficulties appear still to encumber it. The theory of undulations implies the advance and recoil of the elastic medium, and that gives the idea of retardation. The supposition of light being the effect

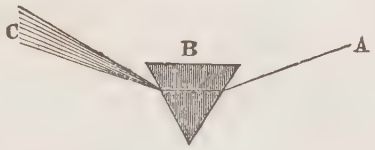
of the motion of an ether, does not fall in with our conceptions of the manner in which it enters into the composition of bodies, or influences chymical combinations, or affects the living powers of animals and vegetables. The merits of the two theories, however, need not be discussed here. It will be sufficient for our purpose to represent a beam of light by a line drawn with the pen, and to enter on the explanation of a few of the laws which influence it in passing through transparent media.



When the ray of light, as A, passes perpendicularly from a rarer into a denser medium, as from air into water, it suffers no change in its direction; but when it passes obliquely, as B, it takes a new direction towards the perpendicular, making a sudden angle, as if broken; and this is refraction. Two circumstances, therefore, influence the ray of light; the angle at which it falls, and the density of the body into which it passes. When the ray B passes from the denser medium into the rarer, it is again refracted, but away from the perpendicular, and takes its original course, provided the surface at which it goes out is parallel to the surface at which it entered.

When a ray strikes upon a body that is not transparent, or only imperfectly so, it is in part reflected, that is, struck off again, bent back, or reflected, and enters the eye, conveying to us the impression of the form and colour of that object.

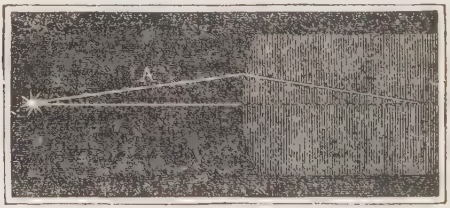
But the expression which we have used requires explanation; for how is it that the reflected rays should convey the idea of colour?



The prism is a piece of glass so formed that the rays must fall obliquely on one or both of the surfaces, and suffer refraction. Thus the ray A striking into the prism B is refracted; but all its parts are not equally refracted; and as the light consists of parts differing in colour, and which are differently refracted, it is divided or dissected into several colours c, called the prismatic colours. The spectrum, as it is termed, thus formed, consists of seven colours; that which is least refracted being red, and in succession orange, yellow, green, blue, indigo, and violet. If these rays be recompounded by passing through a convex lens, which, owing to the obliquity with which they fall, draws them to a point, the focus of the light will be again colourless. Some modern philosophers have reduced these prismatic colours of Newton to three primary colours, red, yellow, and blue; contriving, by the superposition of these, to produce the seven tints; while others have, on considerations not easy to be disproved, held that there is not any definite number of colours, but a gradation of tints, from the extreme red to the extreme violet.

We may now understand the reason of the colour of objects. When light strikes upon a body, even upon the most transparent, part penetrates, part is reflected, and some part is lost. A dye is a disposition given to the surface of cloth to repel some of the rays of light more than the others; and the colour will be according to the ray or the combination of rays thus cast back and sent into the eye.

And here it is natural to reflect on the variety and beauty everywhere bestowed through this property of the beam of light. What a dulness would have pervaded the surface of the earth if there had been only a white light! The beauties of the garden and of the landscape would have been lost to us. How is the beauty of the latter enhanced by the almost infinite variety of colour, yet still within that range which is agreeable and soothing to the eye, as well as consonant to our feelings! The human countenance, too, although capable of exciting our warmest sympathies by form and motion alone, has that beauty perfected by colour, varying under the influence of emotion.



It remains, in order that we may apply these facts to the explanation of the structure of the eye, to show how the rays proceeding from a body and falling upon a convex glass suffer refraction. The ray that strikes upon the centre being perpendicular to the glass, passes on undeviatingly. But each ray, as it strikes a point removed from the centre, must impinge with more obliquity, in consequence of the curved surface; and as the refraction of all the rays will be in proportion to the obliquity of their incidence, they will converge towards the central direct ray. Thus A, as it passes through the glass, suffers refraction towards the perpendicular line, in proportion as it deviated from it on passing out of the air into the glass. These few simple statements may suffice for understanding the comparison which we are now to make between the eye and optical instruments.

X.

THE EYE COMPARED WITH OPTICAL INSTRUMENTS.

We have elsewhere expressed our surprise that the structure of an animal body should so seldom be taken as a model. In the history of inventions, it appears quite extraordinary that the telescope and the microscope should be modern, when, as it should seem, the fine transparent convexity of the eye might have given rise to imitation, as soon as man learned to give shape to natural or artificial glass. It reminds us of the observation of Locke, in speaking of a discovery, that it proved the world to be of no great antiquity. Yet we must estimate the invention of the telescope and microscope as by far the most important in their consequences of either ancient or modern discoveries. The first opens to us an unlimited expanse, not only of new worlds, but systems of worlds, and new laws evinced in the forces which propel and attract these; since in the heavenly bodies we find no material contact, nor pressure, nor impulse, nor transfer of power, nor effect of heat, nor expansion of gases; nothing, in short, which can be illustrated by mechanism. By the microscope we contemplate the minute structure of animals and things, but for its aid invisible: the balance of the cohesive and repulsive forces, as they order the changes in the material of the world, and in that of our own frames. Yet these instruments are not in contrast with the eye: but through the comparison of them we discover the wonderful adaptations of that organ, of which it has long ago been said that it can at one time extend our contemplations to the heavenly bodies and their revolutions, and at another, limit its exercise to things at hand, to the sympathies and affections of our nature visible in the countenance.

If we put aside the consideration of the living properties of the organ, as the extraordinary variety and

degrees of sensibility in the nerve of vision, and confine ourselves to points easily comprehended, as, for example, the mechanism of the eye, and the laws of optics as applicable to the humours, we shall find enough to admire.

When we look upon the optician's lens, however perfect its polish may be, we can see its convex surface: that is to say, the rays of light which strike upon that surface do not all penetrate it, but are in part reflected to our eye, which is the occasion of our seeing it. We do not see the surface of the cornea of the human eye. Here, then, is an obvious superiority, since it implies that all the rays of light which strike the cornea enter it and are refracted, and none are returned to our eye. If we take the optician's lens between our fingers and hold it under water, we can no longer see it, however transparent the water. The reason of this is, that the rays of light are reflected when entering from a rare medium into a denser, more abundantly in proportion to the difference of the density. When the ray of light has penetrated the water, it also penetrates the glass, because there is not that difference of density between the water and the glass which there is between the atmosphere and the glass. From this we may estimate the importance of the surface of the cornea being moistened by the tears; for, however thinly the water may be spread over the surface of the eye, it is sufficient to make those rays that would otherwise be reflected penetrate the cornea.

The whole humours of the eye are constituted with a regard to this law. There is nowhere an abrupt transition from a rare to a dense humour. The ray is transmitted from the cornea into the aqueous humour, and through that humour into the lens or crystalline humour. Were this latter humour uniform, and of the density of its central part throughout, the ray would be in part reflected back from its surface. But it is not uniform, like a mass of glass: it consists of concentric layers, increasing in density from the surface to the centre. If we first look at the entire lens, and then take off its concentric layers, we shall

see the surface of the internal nucleus more distinctly than the exterior and natural surface. The reason is obvious: the nucleus is so much more dense than the atmosphere, that the reflection of the rays from it is more abundant. We now comprehend how finely it is provided that the crystalline lens should be surrounded with the *liquor Morgagni*, a fluid which is but a slight degree more dense than the aqueous humour. The exterior surface of the lens itself is only a little more than the surrounding fluid, and each successive layer, from the surface to the centre, is of gradually increasing density: so that if we were to describe the course of the ray, it would not, as we see in the ordinary diagrams, pass like a straight line of the pen,

but in a curved line, showing the gradual manner in which the ray is refracted through successive transparent layers. As it enters in the anterior half of its passage, it encounters media of increasing density: but as it passes out behind, it is transmitted through media diminishing in density. The ray is nowhere opposed by that sudden increase of density which gives a disposition to reflection; and it passes through the vitreous humour still refracted, the density of that humour having a just correspondence with the posterior surface of the lens. In the atmosphere there is a similar arrangement for receiving the light proceeding from the sun or stars: for as the density of the air diminishes as the height above the earth increases, the surface of our atmosphere, from its rarity, must almost resemble free space; consequently, the light falling into it will penetrate more abundantly than if the air were compressed as it is near the earth, and were of uniform density. We thus see the obvious superiority in the structure of the eye to anything that can be composed of glass, which is of uni-

form density throughout, and must therefore present a succession of surfaces where rare and dense media are abruptly opposed to the rays transmitted.

We may observe another happy result from the peculiar structure of the lens. A magnifying-glass is never true: an aberration of the rays takes place in the pencil of light as the rays are drawn to a focus. The rays which penetrate near the centre are projected so as to be drawn to their focus beyond those rays which pierce through nearer the edge. The rays penetrating the centre of this double convex

glass will project the image to A, while those penetrating nearer the circumference, and, consequently, falling more obliquely, will form a focus nearer the lens at B. But in the crystalline humour of the eye, which corresponds with the optician's lens, the exterior layer having less density, and, therefore, a diminished property of refracting the ray, the image is carried farther off to A; and by this means it is ordered that, wherever the ray penetrates, it shall be drawn to an accurate focus.

Some modern philosophers have asserted that the eye is not perfectly achromatic in every adjustment. The term implies the property of the instrument to represent an image divested of the prismatic colours; those false colours which attend the refraction of the rays of light. If the statement be correct, it is nothing against our argument; nor have those inquirers advanced it with any such view.* We know that in all the ordinary exercises of the eye, the image is perfect, having neither penumbra nor prismatic colours. This property of the eye results from the different media through which the rays are transmitted, and the gradual transmission which we have

* Professor Blair (*Edinburgh Transactions*, iii.) expressly derives an argument in favour of design from this statement of his opinion, and his objection to Boscovich.

just mentioned. Dollond's achromatic glasses, a great improvement upon the telescope, were made on this principle. He composed the object glass of the telescope of crown glass and flint-glass, so that while, by the combined effect of their convexities, they drew the rays to a focus, the dispersive power of the one was counteracted by that of the other.

Let us endeavour to explain this. A, a beam of light, being composed of the different coloured rays, passes through the prism B. (See fig. p. 251.) Instead of passing onward in a straight line, it is refracted to c in distinct, and, consequently, coloured rays. While the whole of them are bent or refracted at an angle from the dotted line, they are also diverging from one another. Their deviation from the straight line is their *refraction:* their diverging from each other is their *dispersion.* These properties being distinct, it is conceivable that glass of a different chymical composition may affect the one to a greater degree than the other, and, therefore, that a lens may be composed of different kinds of glass (crown glass and flint glass, for example), so that the convergence of the rays to a focus may be obtained without the dispersion of the rays, and the consequent production of false colours round the image. This is what Dollond nearly accomplished, and upon these principles. That the effect of this very artificial arrangement is attained in the eye, is a remarkable proof of the perfection of its adaptation to the properties of light.

The last circumstance which we may mention in continuing the comparison, is the drawing out of the tube in the telescope to accommodate the foci of the glasses to the distance of the object. It is sufficient to say that the eye possesses this property of accommodation. That we do not understand how the operation is performed only strengthens the argument in favour of the perfection of the eye; since the power exists, and is exercised with an ease which hardly permits us to be sensible of it.

THE END.

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